



Marine Fisheries REVIEW

March 1982
Vol. 44, No. 3

National Oceanic and Atmospheric Administration • National Marine Fisheries Service



Preserving Pacific Shrimp

Marine Fisheries REVIEW



On the cover: *Pandalus jordani*.
Photograph by William High, NMFS
Northwest and Alaska Fisheries Center,
Seattle, Wash. See the article beginning on page 12.



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National Marine Fisheries Service

Editor: W. Hobart

Marine Fisheries Review (USPS 090-080) is published monthly by the Scientific Publications Office, National Marine Fisheries Service, NOAA, 7600 Sand Point Way N.E., Bin C15700, Seattle, WA 98115.

Single copies and annual subscriptions are sold by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. Prices are: Single copy, \$3.25 domestic, \$4.10 foreign; annual subscription, \$18.00 domestic, \$22.50 foreign. Copies of individual articles, in limited numbers are available from D822, User Services Branch, Environmental Science Information Center, NOAA, Rockville, MD 20852. News items are not reprinted.

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The Secretary of Commerce has determined

that the publication of this periodical is necessary for the transaction of public business required by law of this Department. Use of the funds for printing this periodical has been approved by the Director of the Office of Management and Budget through 30 June 1983.

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Consumer Expenditure Patterns for Fish and Shellfish

ORAL CAPPS, Jr.

Background

A successful seafood industry requires coordination between commercial fishermen and the ultimate consumers. The marketing system coordinates the production decisions of producers with the purchase decisions of consumers. Generally, this coordination is handled by middlemen, the seafood dealers and processors, since only a small part of the total production is sold directly to consumers by commercial fishermen.

This coordination, along with operations and investment planning, requires information on reliable measures of consumer expenditure patterns for fish and shellfish. Price and quantity changes at the consumer level provide signals to processors and commercial fishermen. Information on consumer expenditure for fishery products may lead to the development of processing and storage activities and facilities to increase market outlets. Market research programs are seriously restricted without information on factors affecting consumer expenditure on fishery products. Consumer expenditure information can

also contribute to public decisions which will insure a more uniform flow of raw products to the processing sector.

The share of fish and shellfish expenditure relative to total red meat, poultry, and seafood expenditure has ranged from 5.3 percent to 8.2 percent over the past 30 years (Table 1). Over the same period,

Oral Capps, Jr., is Assistant Professor, Department of Agricultural Economics, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061. This work was sponsored by the Office of Sea Grant, NOAA, under Grant No. 5-29258 and the Virginia Sea Grant Program through Project No. R/SE-3.

ABSTRACT—This study investigates the nature and magnitude of the influence of price, household income, and socioeconomic and demographic variates on aggregate seafood expenditure in the United States. The analysis is based on expenditure patterns of nearly 10,000 households for the years 1972-74.

Socioeconomic and demographic characteristics included: 1) Geographic region, 2) population density, 3) household size, 4) race of household head, 5) marital status of household head, 6) education of household head, 7) occupation of household head, 8) industry of household head, 9) tenure class of household head, 10) seasonality, and 11) employment status of the female household head.

Geographic region, degree of population, density, race, marital status, and industry of the household head influence household expenditure on fish and shellfish. In addition, the price of fish and shellfish, household size, and household income are statistically significant factors in household expenditure on fish and shellfish. Increases (decreases) in price, household size, and household income lead to concomitant increases (decreases) in fish and shellfish expenditure. However, education, occupation, and tenure class of the household head as well as employment status of the female household head and seasonality do not significantly affect household expenditure on fish and shellfish.

Table 1.—Price, per capita consumption, and share of fish and shellfish expenditure relative to total red meat, poultry, and seafood expenditure (Economics and Statistics Service, 1981).

Year	Per capita fish/shellfish consumption (Pounds)	Consumer price index for fish/shellfish (1967 = 100)	Per capita total red meat/poultry/seafood consumption (Pounds)	Consumer price index for total red meat/poultry/seafood (1967 = 100)	Fish/shellfish expenditure share (%)
1950	11.8	73.1	162.3	85.5	6.2
1951	11.2	83.4	157.8	95.6	6.2
1952	11.2	81.3	165.2	94.7	5.8
1953	11.4	78.3	171.7	89.5	5.8
1954	11.2	78.7	171.5	88.0	5.8
1955	10.5	77.1	175.1	82.8	5.6
1956	10.4	77.0	180.7	79.1	5.6
1957	10.2	78.0	174.7	85.8	5.3
1958	10.6	83.4	171.6	93.9	5.5
1959	10.9	84.9	179.8	90.3	5.7
1960	10.3	85.0	178.4	89.1	5.5
1961	10.7	86.9	180.6	89.3	5.8
1962	10.6	90.5	181.9	91.5	5.8
1963	10.7	90.3	187.8	90.1	5.7
1964	10.5	88.2	191.8	88.7	5.4
1965	10.8	90.8	187.4	94.5	5.5
1966	10.9	96.7	193.1	102.6	5.3
1967	10.6	100.0	200.8	100.0	5.3
1968	11.0	101.6	204.5	102.2	5.3
1969	11.2	107.2	206.1	110.8	5.3
1970	11.8	117.8	211.7	116.5	5.6
1971	11.5	130.2	217.0	116.9	5.9
1972	12.5	141.9	216.9	128.0	6.4
1973	12.9	162.8	204.7	160.4	6.4
1974	12.2	187.7	214.7	163.9	6.5
1975	12.3	203.3	207.0	178.1	7.8
1976	13.1	227.3	221.0	179.4	7.5
1977	12.9	251.6	221.7	178.4	8.2
1978	13.6	275.4	219.7	208.3	8.2
1979	13.3	302.3	222.0	239.3	7.6
1980	13.5	328.6	226.7	247.9	7.9

the annual per capita consumption of fish and shellfish has trended gradually upward from 10.2 pounds to 13.6 pounds. Generally, consumer expenditure patterns depend upon prices, income, and socioeconomic and demographic characteristics. However, a paucity of information exists as to how such factors affect consumer expenditure for fish and shellfish.

Socioeconomic and demographic forces, particularly household size and age/sex composition, place of residence (region), and population density (degree of urbanization), may exert notable influences on fish and shellfish expenditure. This hypothesis is primarily attributable to shifts in the response of consumption to the life cycle, differences in accessibility of the products, differences in climate, and the development of consumer buying habits.

The age distribution of the U.S. population is in the process of change. Between 1970 and 1978, the number of persons 65 years of age and over rose at almost three times the rate of the rest of the U.S. population (Gallo et al., 1979). Single or two-person households are more commonplace, and the Census Bureau projects that over one-fourth of all U.S. households will consist of only a single person by 1990 (Sexauer and Mann, 1979). In addition, a number of studies of specific household expenditures indicate that race, education, occupation, industry, tenure class (home ownership), marital status, seasonality, and employment status of the female head are statistically important factors (Brown and Deaton, 1972; Ferber, 1973; Buse and Salathe, 1979). The impact of these socioeconomic and demographic characteristics is likely to reflect, in part, differences in tastes and preferences, culture, and infrastructure of households.

To enhance the understanding of fish and shellfish buying patterns in the United States, this study investigates the nature and magnitude of the influence of price, household income, and socioeconomic and demographic variates on aggregate seafood expenditure. The list of socioeconomic and demographic characteristics encompasses: 1) Geographic region, 2) population density, 3) household size, 4) race of household

head, 5) marital status of household head, 6) education of household head, 7) occupation of household head, 8) industry of household head, 9) tenure class (homeownership) of household head, 10) seasonality, and 11) employment status of the female household head.

The aggregate fish and shellfish analysis is limited to this set of characteristics due to the unavailability of additional information. The source of data is the 1972-74 U.S. Bureau of Labor Statistics (BLS) Consumer Expenditure Diary Survey. This survey provides a comprehensive source of expenditure and income information in relation to socioeconomic and demographic characteristics of households in the United States (Capps et al., 1981). The source of price information is the Consumer Price Index for fish and shellfish.

Stolting et al. (1955), Purcell and Raunikaar (1968), and Nash (1971) conducted research studies employing household survey data to investigate consumer expenditure patterns for fish and shellfish. This study builds on the foundation of the previous efforts by using more recent data and more sophisticated statistical techniques. A discussion of the data base and the statistical model is presented in subsequent sections. The fourth section deals with the results of the analysis. Concluding comments are given in the fifth section.

Data

The data source for this study is the 1972-74 BLS Consumer Expenditure Diary Survey. The survey covers the noninstitutional population of the United States in two samples of 12-month periods from June 1972 to June 1973 and July 1973 to June 1974. The time period is short enough so that consumer preferences are stable, yet long enough to accommodate the diversity of consumer choices. The sample for each survey year was partitioned into 52 weekly subsamples, to cover the entire calendar year and to expose seasonal variations in expenditure patterns. The first survey year included 11,065 households while the second survey year included 12,121 consumer units. Participants listed all expenditures during two consecutive 7-day periods, except for those while

away from home overnight on trips or vacations.

All data were collected through the voluntary cooperation of households. Two separate collection vehicles served to obtain the data: 1) An interviewer-administered household characteristics questionnaire, and 2) a separate diary to record daily expenses over a 2-week period. The first type of collection vehicle recorded socioeconomic and demographic information pertaining to the household, and the second type of collection vehicle provided a self-reporting, product-oriented daily expense record. The diary questionnaire was divided by day of purchase and by broad classification of goods and services to aid the respondent when recording daily purchases and to facilitate the coding of individual purchases.

The sample used for this analysis includes nearly 10,000 households (roughly 40 percent of the BLS households participating in the Consumer Expenditure Diary Survey) that reported income and fish and shellfish expenditure information. For the sample, the mean and median 2-week expenditure for fish and shellfish is \$2.81 and \$1.72, respectively. The minimum expenditure is \$0.03 and the maximum expenditure is \$100.65. The mean and median percentage of total food expenditure for fish and shellfish is 4.04 and 2.61 percent, respectively. In contrast, the mean and median 2-week expenditure for total food is \$81.28 and \$72.47, respectively. The minimum expenditure for total food is \$1.17 and the maximum expenditure is \$697.76. In general, mean and median 2-week household expenditure as well as mean and median percentage of total food expenditure for fish and shellfish vary substantially across income levels and classifications of socioeconomic and demographic characteristics.¹

Model

A variety of functional forms has been suggested to represent household expenditure behavior. All hypothesize that household expenditure is related to price, household income, and numerous so-

¹For details, see Capps et al. (1981).

cioeconomic and demographic characteristics. The most widely used include the 1) linear, 2) quadratic, 3) double logarithmic, 4) semilogarithmic, 5) inverse, and 6) logarithmic-inverse functional forms (Prais and Houthakker, 1955; Goreaux, 1960; Leser, 1963; Brown and Deaton, 1972; Hassan and Johnson, 1977; Salathe, 1979; Smallwood and Blaylock, 1981). This study hypothesizes the quadratic function as the form of the aggregate fish and shellfish expenditure function.

The quadratic form possesses properties set forth by demand theory and may be thought of as a second-order Taylor series expansion in household income and household size to a general expenditure function (Howe, 1977). In addition, Salathe (1978) found that the quadratic form more accurately described expenditure behavior when comparing empirically alternative functional forms.

The mathematical form of the quadratic function used is:

$$\begin{aligned}
 FISH = & A_0 + A_1 GR2 + A_2 GR3 \\
 & + A_3 GR4 + A_4 L2 + A_5 L3 \\
 & + A_6 L4 + A_7 L5 + A_8 L6 \\
 & + A_9 L7 + A_{10} L8 + A_{11} R1 \\
 & + A_{12} M1 + A_{13} E1 + A_{14} E2 \\
 & + A_{15} E3 + A_{16} E4 + A_{17} E5 \\
 & + A_{18} OC1 + A_{19} OC2 + A_{20} OC3 \\
 & + A_{21} OC4 + A_{22} OC5 + A_{23} OC6 \\
 & + A_{24} OC7 + A_{25} OC8 + A_{26} OC9 \\
 & + A_{27} I1 + A_{28} I2 + A_{29} I3 \\
 & + A_{30} I4 + A_{31} I5 + A_{32} I6 \\
 & + A_{33} I7 + A_{34} I8 + A_{35} H1 \\
 & + A_{36} FH1 + A_{37} S1 + A_{38} S2 \\
 & + A_{39} S3 + A_{40} PR \\
 & + A_{41} FAMSIZE + A_{42} FSQ \\
 & + A_{43} TOTLINC + A_{44} INSQ \\
 & + A_{45} FSINC + e. \quad (1)
 \end{aligned}$$

The parameters A_0, A_1, \dots, A_{45} are the coefficients that measure the response of fish and shellfish expenditure to changes in price, household income, household size, and socioeconomic and demographic variates. The random variable e represents the stochastic disturbance term of the quadratic expenditure function. The independent variables $GR2, GR3, GR4, L2, L3, L4, L5, L6, L7, L8, R1, M1, E1, E2, E3, E4, E5, OC1, OC2, OC3, OC4, OC5, OC6, OC7,$

Table 2.—List of variable names.	
Item	
<i>FISH</i> - Fish and shellfish expenditure	
<i>GR1</i> - Northeast region	(omitted category)
<i>GR2</i> - North Central region	
<i>GR3</i> - South region	
<i>GR4</i> - West region	
<i>L1</i> - SMSAs 1,000,000+ population/central cities	(omitted category)
<i>L2</i> - SMSAs 1,000,000+ population/other than central cities	
<i>L3</i> - SMSAs 400,000 to 999,999 population/central cities	
<i>L4</i> - SMSAs 400,000 to 999,999 population/other than central cities	
<i>L5</i> - SMSAs 50,000 to 399,999 population/central cities	
<i>L6</i> - SMSAs 50,000 to 399,999 population/other than central cities	
<i>L7</i> - Outside SMSAs/urban	
<i>L8</i> - Outside SMSAs/rural	
<i>FAMSIZE</i> - Household size	
<i>R1</i> - White and other than Black	
<i>R2</i> - Black	(omitted category)
<i>M1</i> - Married	
<i>M2</i> - Widowed, divorced, separated, never married	(omitted category)
<i>E1</i> - Some grade school completed	
<i>E2</i> - Some high school completed	
<i>E3</i> - High school graduate	
<i>E4</i> - Some college completed	
<i>E5</i> - College graduate, graduate work	
<i>E6</i> - None	(omitted category)
<i>OC1</i> - Self-employed	
<i>OC2</i> - Salaried professional, technical worker	
<i>OC3</i> - Salaried managers, administrators	
<i>OC4</i> - Clerical	
<i>OC5</i> - Sales	
<i>OC6</i> - Craftsmen	
<i>OC7</i> - Operatives	
<i>OC8</i> - Unskilled laborers	
<i>OC9</i> - Retired	
<i>OC0</i> - Other	(omitted category)
<i>I1</i> - Agriculture, forestry, fishing, mining	
<i>I2</i> - Construction	
<i>I3</i> - Manufacturing	
<i>I4</i> - Transportation, communications, utilities, finance, insurance, real estate	
<i>I5</i> - Trade	
<i>I6</i> - Nonprofessional service	
<i>I7</i> - Professional service	
<i>I8</i> - Public administration	
<i>I0</i> - Other	(omitted category)
<i>TOTLINC</i> - Household income	
<i>H1</i> - Homeowner	
<i>H2</i> - Renter	(omitted category)
<i>FH1</i> - Employed female head	
<i>FH2</i> - Unemployed female head	(omitted category)
<i>S1</i> - Winter quarter	
<i>S2</i> - Spring quarter	
<i>S3</i> - Summer quarter	
<i>S4</i> - Fall quarter	(omitted category)
<i>PR</i> - Consumer price index of fish, shellfish	
<i>FSQ</i> - Family size squared	
<i>INSQ</i> - Total money income squared	
<i>FSINC</i> - Interaction of family size and income	

¹SMSA refers to Standard Metropolitan Statistical Area.

$OC8, OC9, I1, I2, I3, I4, I5, I6, I7, I8, H1, FH1, S1, S2,$ and $S3$ are binary or zero-one variables. Zero-one variables in this study take on the value of unity with the occurrence of a particular attribute and take on the value of zero with the nonoccurrence of a particular attribute. For example, when the variable $GR2$ is equal to one, this representation implies that the household is located in

the North Central region of the United States. When the variable $GR2$ is equal to zero, this representation indicates that the household is located either in the Northeast, the South, or the West. The list of variable names is exhibited in Table 2.

Most of the independent variables in the statistical model are zero-one variables. The key purpose of the use of zero-one variables is to achieve a greater degree of generalization in model formulation. The binary variables are intercept shifters, not slope shifters, of the quadratic expenditure function. The coefficients of the binary variables reflect the impact of region, population density, race of the household head, marital status of the household head, education of the household head, occupation of the household head, industry of the household head, tenure class of the household head, employment status of the female head, and seasonality on fish and shellfish expenditure.

When using zero-one variables, classifications of the socioeconomic and demographic variates have to be established so that they are mutually exclusive and exhaustive. The number of ones in each classification represents the number of replications. To handle the singularity problem (the sum of all zero-one variables of a particular socioeconomic and demographic variate forms a perfect linear association with the intercept of the statistical model), one of the zero-one variables of each set of classifications is arbitrarily deleted. Hence A_0 , the intercept of the quadratic function, represents confounded components — some general intercept for the statistical model and the effects of omitted zero-one variables from each set of classifications of socioeconomic and demographic variates. Technically, A_0 is the base intercept of the expenditure function. The coefficients of the binary variables indicate the numerical amount by which the included classifications of the set of discrete variables differs from the base intercept.

Elasticities can be computed from (1) to summarize the influence of price, household size, and household income on fish and shellfish expenditure. The income elasticity measures the percent-

age change in fish and shellfish expenditure due to a 1 percent change in income. The income elasticity implied by (1) is given by:

$$\eta = \frac{(\partial FISH / \partial TOTLINC)}{(TOTLINC / FISH)} \\ \eta = (A_{43} + 2A_{44} TOTLINC + A_{45} FAMSIZ) (TOTLINC / FISH), \quad (2)$$

where $(\partial FISH / \partial TOTLINC)$ is the partial derivative of *FISH* with respect to *TOTLINC*; (2) implies that the value of the income elasticity depends upon the expenditure level, income, and household size. A negative income elasticity indicates that expenditures on fish and shellfish decline (rise) as income increases (decreases). A positive income elasticity indicates that expenditures on fish and shellfish rise (decline) as income increases (decreases). The larger the magnitude of the income elasticity, the more responsive fish and shellfish expenditures are to changes in household income.

The household-size elasticity measures the percentage change in fish and shellfish expenditure due to a 1 percent change in household size. The household-size elasticity associated with (1) is given by:

$$\delta = \frac{(\partial FISH / \partial FAMSIZ)}{(FAMSIZ / FISH)} \\ \delta = (A_{41} + 2A_{42} FAMSIZ + A_{43} TOTLINC) (FAMSIZ / FISH), \quad (3)$$

where $(\partial FISH / \partial FAMSIZ)$ is the partial derivative of *FISH* with respect to *FAMSIZ*; (3) implies that the value of the household-size elasticity depends upon the expenditure level, income, and household size. A positive (negative) household-size elasticity indicates that expenditures on fish and shellfish rise (decline) as household size increases. The larger the magnitude of the household-size elasticity, the more responsive fish and shellfish expenditures are to changes in household size.

The price elasticity of demand measures the percentage change in fish and shellfish consumption due to a 1 percent change in price. The price elasticity of

demand associated with (1) is given by:

$$\epsilon = [(\partial FISH / \partial PR) (PR / FISH)] - 1 \\ \epsilon = [A_{40} (PR / FISH)] - 1, \quad (4)$$

where $(\partial FISH / \partial PR)$ is the partial derivative of *FISH* with respect to *PR*; (4) implies that the value of the price elasticity of demand depends upon the expenditure level and the price level. A positive value of A_{40} indicates that the demand for fish and shellfish is inelastic. Increases (decreases) in fish and shellfish price lead to concomitant increases (decreases) in fish and shellfish expenditure. A negative value of A_{40} indicates that the demand for fish and shellfish is elastic. Increases (decreases) in fish and shellfish price lead to concomitant decreases (increases) in fish and shellfish expenditure. The larger the magnitude of the price elasticity, the more responsive fish and shellfish expenditures are to changes in price. The sample means of *FISH*, *TOTLINC*, *FAMSIZ*, and *PR* are used in this study for calculating the price, income, and household-size elasticities.

Since both zero-one and continuous quantitative variables are components of the quadratic model, this formulation is, technically speaking, a multiple covariance model. Analysis of covariance is the combination or the blending of multiple regression and analysis of variance. The covariates in this study are price, household size, and household income.

Results

The estimation of the coefficients of the quadratic expenditure function was accomplished through the use of ordinary least squares. The regression analysis for the quadratic functional form is exhibited in Table 3. The Durbin-Watson D statistic indicates the absence of autocorrelation in the disturbance term of the statistical model. Slightly more than 5 percent of the variation in household expenditure on fish and shellfish is accounted for by the set of regressors in the quadratic expenditure model. Although not shown due to space limitations, the matrix of correlation coefficients for regressors in the quadratic expenditure function indicates the

absence of multicollinearity problems.

The estimated coefficients of the zero-one variables represent incremental differences relative to the base intercept. Tests of hypotheses about the individual parameters of the zero-one variables provide information about whether the intercepts for each of the included classifications of discrete variables are different from the omitted classifications.

The *t*-test is used to perform tests of significance about the estimated coefficients of binary variables and about the estimated coefficients of continuous quantitative variables. To test hypotheses about all possible pairs of differences among the parameters of the zero-one variables within particular socio-

Table 3.—Regression analysis for the quadratic expenditure function.

Variable	Parameter estimate	Standard error	T-ratio	P-value
INTERCEPT	1.801036	0.641712	2.8066	0.0050
GR2	-0.912618	0.108785	-8.3892	0.0001
GR3	-0.515220	0.108005	-4.7704	0.0001
GR4	-0.360134	0.116227	-3.0986	0.0020
L2	-0.698991	0.117210	-5.9713	0.0001
L3	-0.539719	0.181428	-2.9748	0.0029
L4	-0.620412	0.178563	-3.4745	0.0005
L5	-0.948617	0.171233	-5.5399	0.0001
L6	-0.745032	0.172914	-4.3087	0.0001
L7	-0.600488	0.143214	-4.1929	0.0001
L8	-0.783947	0.142787	-5.4903	0.0001
FAM-SIZE	-0.320238	0.085181	3.7595	0.0002
R1	-0.768427	0.137179	-5.6016	0.0001
M1	-0.308821	0.125770	2.4554	0.0141
E2	-0.231905	0.402880	-0.5759	0.5847
E3	-0.239230	0.407235	-0.5875	0.5569
E4	-0.257692	0.403787	-0.6382	0.5234
E5	-0.355718	0.411748	-0.8639	0.3877
E6	-0.251917	0.415902	-0.6057	0.5447
OC1	0.370868	0.331973	1.1172	0.2640
OC2	0.328923	0.304975	1.0785	0.2808
OC3	0.461138	0.309447	1.4902	0.1362
OC4	0.355045	0.309821	1.1460	0.2518
OC5	0.235168	0.350053	0.6718	0.5017
OC6	0.229753	0.303300	0.7575	0.4488
OC7	0.209574	0.306458	0.6838	0.4941
OC8	0.381418	0.298858	1.2763	0.2019
OC9	0.033657	0.204221	0.1648	0.8891
I1	-0.714158	0.400294	-1.7841	0.0744
I2	-0.564825	0.364551	-1.5494	0.1213
I3	-0.737871	0.342395	-2.1550	0.0312
I4	-0.579322	0.351637	-1.6475	0.0995
I5	-0.481109	0.351257	-1.3697	0.1708
I6	-0.458026	0.368792	-1.2420	0.2143
I7	-0.371113	0.353738	-1.0491	0.2942
I8	-0.277728	0.320480	-0.8666	0.3862
TOT-LINC	0.0004958735	0.0000118872	4.1715	0.0001
H1	0.062107	0.089856	0.6912	0.4895
FH1	-0.132897	0.091600	-1.4508	0.1469
S1	0.104934	0.105613	0.9936	0.3205
S2	0.126396	0.109415	1.1552	0.2480
S3	0.043687	0.108251	0.4036	0.6865
PR	0.902193	0.264031	3.4170	0.0006
FSQ	-0.00889571	0.00873766	-1.0818	0.3087
INSQ	2.90141E-10	8.65610E-11	3.3519	0.0008
FSINC	-0.0000056173	0.0000256571	-2.1894	0.0286

SSE 118734 F-ratio 11.13
DPE 9020 P-value 0.0001
MSE 13.163413 R-squared 0.0526
Durbin-Watson D statistic = 1.9535
First order autocorrelation coefficient = 0.0232
Source: Computations by the author.

economic and demographic classifications, the Newman-Keuls procedure is used. The Newman-Keuls test, a sequential range test, is designed to overcome the problem of the changing level of significance when conventional statistical tests for ascertaining differences among pairs of parameters are applied to sets of nonorthogonal differences.² The basic notion underlying this test is that the ranges of differences specified as significant at a chosen level of significance are systematically adjusted depending upon the number of coefficients in the particular classifications so as to offset the loss of the level of significance.³

The *P*-value summarizes what the data say about the credibility of the null hypothesis $H_0: A_i = 0, i=1, 2, \dots, 45$ for the quadratic expenditure model. The null hypothesis is rejected if the *P*-value is less than the specified level of significance. The significance level chosen for this research study is 0.10.

Households located in the Northeast purchase significantly more fish and shellfish than households located in the North Central region, the South, and the West. In addition, households located in the South and the West spend significantly more on fish and shellfish than households located in the North Central region. No statistically significant differences exist in fish and shellfish expenditure patterns between households in the South and in the West. Further, households located in Standard Metropolitan Statistical Areas (SMSA's) with 1,000,000 or more population spend significantly more on fish and shellfish than households located in less densely populated areas. Fish and shellfish expenditure for households located in SMSA's with 400,000 to 999,999 popu-

lation, SMSA's with 50,000 to 399,999 population, and urban and rural areas outside SMSA's is statistically the same.

Household heads in agriculture, forestry, fishing, mining, construction, manufacturing, transportation, communications, utilities, finance, insurance, and real estate industries expend significantly less on fish and shellfish than household heads in other industries. All other differences in fish and shellfish expenditure among industries of household heads are statistically nonsignificant. Education of the household head, occupation of the household head, tenure class of the household head, employment status of the female head outside the home, and seasonality are not statistically important factors in explaining the variation in household expenditure on fish and shellfish. Blacks and married persons, however, expend significantly more on fishery products than nonblacks and nonmarried persons.

In sum, test of significance indicate that geographic region, population density, race, marital status, and industry of the household head influence household expenditure on fish and shellfish. On the other hand, education, occupation, employment status of the female head outside the home, tenure class of the household head, and seasonality do not significantly affect household expenditure on fish and shellfish.

The price of fish and shellfish, household size, and household income are statistically significant factors in household expenditure on fish and shellfish. In the quadratic expenditure model, increases (decreases) in price, household size, and household income lead to con-

comitant increases (decreases) in household expenditure on fish and shellfish. A 10 percent change in household income is positively associated with a 1.68 percent change in aggregate fish and shellfish expenditure. This measure indicates that fish and shellfish is a normal good. Similarly, a 10 percent change in household size is positively associated with a 2.30 percent change in aggregate fish and shellfish expenditure. The price elasticity of demand for fish and shellfish is inelastic. A 10 percent change in price leads to a 4.67 percent change in fish and shellfish consumption in the opposite direction. On the basis of the estimated coefficients of price in the statistical model, a 10 percent increase (decrease) in the price of fish and shellfish leads to a 5.32 percent increase (decrease) in fish and shellfish expenditure.

The estimated quadratic expenditure model may be used to make predictions of 2-week household expenditure on fish and shellfish given information on price, household income, household size, and socioeconomic and demographic characteristics. Various socioeconomic and demographic profiles can be constructed to examine household expenditure behavior. To illustrate, two profiles of 2-week household expenditure on fish and shellfish by household income and household size are presented in Tables 4 and 5.

The first profile incorporates the following socioeconomic and demographic characteristics: 1) The household is located in the Northeast, 2) the household is located in a central city within a SMSA of 1,000,000 and over population, 3) the household head is black, 4) the head of

²The basic problem with testing all possible pairs is that the level of significance decreases as the number of nonorthogonal comparisons increases. One may be performing tests of hypotheses at some chosen level of significance when in fact the true level of significance may be considerably less. The outcome is that too many differences are judged to be statistically significant at a chosen significance level.

³For the presentation of pairwise comparisons for estimated coefficients of the statistical model by socioeconomic and demographic variates based on the Newman-Keuls test, see Capps et al. (1981).

Table 4.—Profile 1: Predictions of 2-week household expenditure by household income and by household size.¹

Household income	Household size (no. of members)				
	One	Two	Three	Four	Five
\$ 2,000	\$4.47	\$4.75	\$5.02	\$5.27	\$5.49
\$ 5,000	\$4.61	\$4.88	\$5.12	\$5.35	\$5.57
\$10,000	\$4.85	\$5.09	\$5.31	\$5.51	\$5.69
\$15,000	\$5.11	\$5.32	\$5.51	\$5.68	\$5.84
\$20,000	\$5.38	\$5.56	\$5.72	\$5.87	\$6.00
\$25,000	\$5.66	\$5.82	\$5.95	\$6.07	\$6.17
\$35,000	\$6.28	\$6.37	\$6.45	\$6.51	\$6.56
\$50,000	\$7.31	\$7.32	\$7.31	\$7.29	\$7.25

¹Source: Computations by the author.

Table 5.—Profile 2: Predictions of 2-week household expenditure by household income and by household size.¹

Household income	Household size (no. of members)				
	One	Two	Three	Four	Five
\$ 2,000	\$2.54	\$2.82	\$3.09	\$3.34	\$3.56
\$ 5,000	\$2.68	\$2.95	\$3.19	\$3.42	\$3.64
\$10,000	\$2.92	\$3.16	\$3.38	\$3.58	\$3.76
\$15,000	\$3.18	\$3.39	\$3.58	\$3.75	\$3.91
\$20,000	\$3.45	\$3.63	\$3.79	\$3.94	\$4.07
\$25,000	\$3.73	\$3.89	\$4.02	\$4.14	\$4.24
\$35,000	\$4.35	\$4.44	\$4.52	\$4.58	\$4.63
\$50,000	\$5.38	\$5.39	\$5.38	\$5.36	\$5.32

¹Source: Computations by the author.

the household is separated, 5) the household head is a high school graduate, 6) the household head is self-employed, 7) the household head is in the construction business, 8) the household head is a renter, 9) the female household head is unemployed and 10) the season is the fall quarter. The second profile embodies the following socioeconomic and demographic characteristics: 1) The household is located in the South, 2) the household is located in a rural area outside a SMSA, 3) the household head is white, 4) the household head is married, 5) the household head has completed some high school, 6) the household head is an unskilled laborer, 7) the household head is in the manufacturing business, 8) the household head is a homeowner, 9) the female household head is employed, and 10) the season is the summer quarter. The price used for the arrangement of these profiles is the annual average Consumer Price Index of fish and shellfish for 1979 (3.023).

For example, a household with an annual income of \$20,000 and five family members that fits the specification of the first profile would spend \$6.00 biweekly for fish and shellfish. Similarly, a household with the same annual income and family size that fits the specification of the second profile would spend \$4.07 biweekly for fish and shellfish. In general, for any socioeconomic and demographic profile, as household size increases (decreases) *ceteris paribus*, or as household income increases (decreases) *ceteris paribus*, the expenditure on fish and shellfish also increases (decreases). The tremendous wealth of detail in the classifications of the socioeconomic and demographic variates permits the construction of 1,105,920 unique profiles of

the type in Tables 4 and 5. The reader is left to pursue those which are of the most interest to him. Such profiles are useful for market research programs by the seafood industry.

Concluding Comments

A logical generalization is to extend the analysis to focus on individual fish and shellfish species such as hard blue crabs, oysters, clams, and food finfish. A second generalization involves the examination of the impact of additional socioeconomic and demographic characteristics such as religion and age-sex composition of the household on fish and shellfish expenditure. A third generalization encompasses the use of the 1977-78 Nationwide Food Consumption Survey. A comparison of household expenditure patterns of fish and shellfish from the 1972-74 Consumer Expenditure Diary Survey and from the 1977-78 Nationwide Food Consumption Survey provides indications of stability or instability of consumer behavior in the seafood market. The last decade was characterized by dramatic changes in price, household income, and socioeconomic and demographic characteristics. Additional studies of household expenditure behavior are likely to pay dividends to the seafood industry.

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A Study in the Use of a High Concentration of CO₂ in a Modified Atmosphere to Preserve Fresh Salmon

HAROLD J. BARNETT, FREDERICK E. STONE, GLENN C. ROBERTS,
PATRICK J. HUNTER, RICHARD W. NELSON, and JOSEPHINE KWOK

Introduction

The preservative effects of carbon dioxide (CO₂) on protein foods has been known for many years and is used to preserve perishables, such as meats and poultry. Early research by Coyne (1932), Stansby and Griffiths (1935), and others showed that CO₂ atmospheres have a beneficial preservative effect on certain species of bottomfish.

More recently, the National Marine Fisheries Service (NMFS) in cooperation with Whirlpool Corporation¹ (Nelson and Tretsen, 1975) made a series of laboratory experiments to determine the preservative effects of controlled atmospheres (CA) on fresh Pacific salmon, *Oncorhynchus* spp. Results from these studies showed that the shelf life of refrigerated salmon could be significantly extended by storage in a CA containing 11.5 percent CO₂, 87 percent nitrogen (N₂), and 1.5 percent oxygen (O₂). Until

recently, however, commercial use of controlled atmosphere or modified atmosphere (MA) to preserve fish was not seriously considered for use by the industry because of economic and technical considerations.

Then in 1977, a salmon processor demonstrated interest in the techniques by making a few exploratory shipments of fresh salmon in special refrigerated vans from Alaska to the Pacific Northwest. The interest, of course, was created by the increased value of salmon and changing markets. The shipments, made in MA containing high concentrations of CO₂ and O₂, demonstrated the potential for improving the keeping quality of fresh salmon shipped in large containers or vans.

Harold J. Barnett, Research Chemist; Frederick E. Stone, Chemist; Glenn C. Roberts, Chemist; Patrick J. Hunter, Engineering Technician; and Richard W. Nelson, Supervisory Chemical Engineer, are with the Utilization Research Division, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, 2725 Montlake Boulevard East, Seattle, WA 98112. Josephine Kwok, Food Technologist, was with the New England Fish Company, Pier 89, Seattle, WA 98119.

Problems appeared in the early tests, e.g., undesirable changes in quality in the salmon were found in several shipments. Changes in quality were related to inadequate cooling of the fish after catching and during handling and processing as well as to problems in adapting packaging for shipment. The latter consisted of using Wet-Lok-type containers, which were perforated to allow for removal of drip and free passage of the MA. Drying, caused by the vans' forced-air refrigeration system, resulted in product shrinkage and loss of quality through oxidation and discoloration. The high concentration of oxygen used in the MA gas mixture was thought to be a contributing factor to the oxidation and discoloration problem. The problem of drying was partly controlled by top icing the boxed fish for shipment.

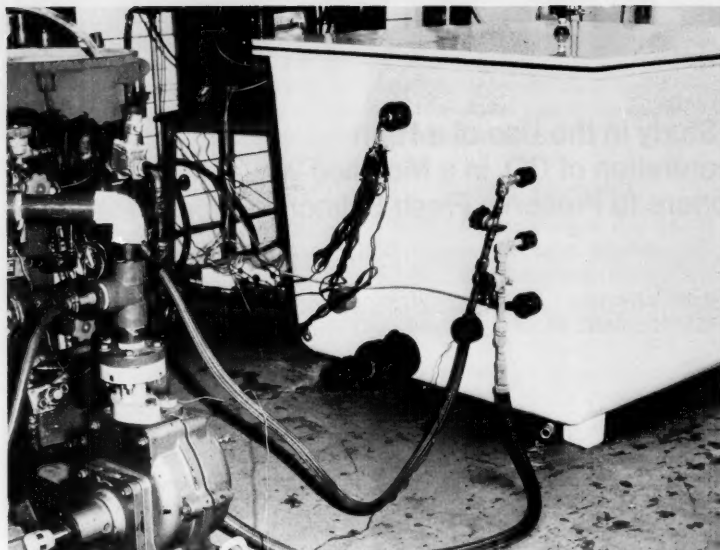
Because of the need for more information, we initiated studies to investigate the variables of low temperature and high concentration of CO₂ gas as an effective mechanism to control the quality of fresh Pacific salmon held in MA.

In recent studies by Williams et al. (1978), it was found that at 5°C (41°F),

ABSTRACT—Commercial use of modified atmospheres to preserve fish during shipment has been limited because of economic and technical reasons. Recent interest in the use of the technique to ship Pacific salmon, *Oncorhynchus* spp., out of Alaska has demonstrated the need for additional information to improve handling and shipping procedures. Studies were conducted to determine the effect of low storage temperature

combined with the use of a high concentration of CO₂ gas as an effective combination for controlling the quality of fresh Pacific salmon held in modified atmospheres. Salmon were held in acceptable condition for 21 days in a modified atmosphere containing 90 percent CO₂. The effect of the CO₂ was to slow the growth of spoilage bacteria extending the fresh shelf life of the salmon from about 12 days on ice to 21 days in the modified atmos-

phere. Carbon dioxide absorbed in the flesh of the salmon causes some swelling in the canned product but the condition can be controlled. The modified atmosphere method described can be considered for commercial use. Recommendations are made for handling the salmon for shipping and for additional research on the preservative effects of CO₂ and other atmospheres with respect to different fish species.



Figures 1.—Modified atmosphere container showing refrigeration flex lines, stainless steel "pop-off" valve on lid, and thermocouples connected to a multipoint recorder (shown to the left rear of container).

growth of bacteria, predominantly associated with the spoilage of fish, was almost totally inhibited by a 100 percent CO_2 atmosphere. In tests made by the Northwest and Alaska Fisheries Center's Utilization Research Division, Seattle, Wash., in cooperation with a local fish-processing company, walleye pollock and Pacific cod stored at 0°C (32°F) in a MA containing 90 percent CO_2 and 10 percent air were judged superior in quality to walleye pollock and Pacific cod stored at 0°C (32°F) in atmospheres containing 20 percent and 55 percent CO_2 . Based on this knowledge, it was decided to investigate the use of the higher concentrations of CO_2 than now commercially used for shipping salmon in MA.

In this experiment, fresh, fall-caught butchered Pacific salmon were held at 0°C (32°F) in the MA for 21 days. This report describes the rationale and results of the experiment. In view of the continuing interest of the salmon canning industry in methods of extending the keeping quality of salmon prior to can-

ning, a limited study was made of the potential use of MA-stored salmon for canning.

The Modified Atmosphere System

Laboratory equipment for this experiment consisted of a portable freon-12 refrigeration unit modified with a hot-gas, bypass system to maintain a partial load, at temperature, to prevent periodic cycling of the compressor. The system was designed to maintain uniform product temperatures within $\pm 1^\circ\text{F}$ (0.6°C).

The container (Fig. 1) used to store the fish was of a special design. Portable and constructed of fiberglass, it had a 1,700-pound fish-holding capacity and was insulated with 4 inches of urethane foam. Stainless steel chiller plates (coils) mounted on the inner walls were connected via special bulkhead fittings to the refrigeration unit by standard refrigeration flex lines. The false floor of the tank was perforated to allow excess melted ice, water, and drip to drain from the fish during storage. The top of the container was gasketed to facilitate mak-

ing the container airtight. One-quarter-inch, stainless steel needle valves, located near the bottom of one side and on top of the lid, provided the necessary filling and venting ports for gassing the storage container. A stainless steel "pop-off" valve located on the lid prevented pressurizing the container. A multipoint recorder, equipped with stainless steel, sabretype thermocouples, was used to measure and record the internal temperatures of the storage container and fish.

The equipment described here was used only to simulate commercial conditions. Less elaborate, light-weight, multipurpose, plastic fish totes that can be made airtight for use with gases and shipped in refrigerated vans or by air are now being designed for commercial use.

Besides eliminating some of the previously described drawbacks of using cardboard containers, airtight bulk containers could expedite handling and packing of salmon as well as reduce costs. Such containers could also increase the potential for using the MA method in remote areas, such as Alaska's Bristol Bay. The containers could be multipurpose and made in a variety of sizes for shipping on vessels, by air, and in refrigerated vans or used to bulk store fish in processing plants. This could be especially useful during peak operating times.

Materials and Methods

Sample Preparation and Procedures

The 310 pounds of salmon used in this experiment consisted of mature coho, *Oncorhynchus kisutch*, and chum, *O. keta*, salmon that had been gillnetted in Puget Sound about 24 hours prior to beginning the experiment. They were headed and gutted and well iced shortly after being caught. The internal temperature of the fish when loaded in the container was about 32°F (0°C). Many fish showed signs of water marking and loss of brightness of color but were otherwise of very good quality. In the laboratory, the salmon were removed from the ice and placed randomly in the storage container. Thermocouples were inserted into two of the fish, one located on the bottom of the load and one on the

very top. Other probes were placed inside the holding tank to measure the internal ambient temperature which was maintained at 32°F (0°C) during the experiment. The storage container was then sealed and purged with CO₂ gas to obtain an atmosphere mixture containing 90 percent CO₂ and 10 percent air. The exact concentration of the gas was determined with a Burrell gas analyzer. The CO₂ gassing procedure was repeated each time the container was opened to examine and sample the fish.

The salmon were periodically sampled and evaluated for quality during the 21-day experiment. Criteria included sensory attributes, chemical and physical changes, and total aerobic bacterial plate counts. At each examination period, two fish were randomly sampled from storage, split along the long axis with one-half of each fish retained for bacteriological examination. Each of the remaining sides was evaluated chemically and organoleptically. Chemical analyses were made in duplicate of each fish.

Two additional fish were selected at each examination period, washed, frozen, glazed, vacuum sealed in a polyethylene bag, and stored at -18°C (-20°F) for future chemical and sensory examination. In addition, two fish were randomly selected at intervals from MA storage, washed, trimmed, sectioned, and packed in 1/2-pound cans and thermally processed. Cans were air-cooled and stored at ambient room temperature.

Analytical Methods

Total aerobic plate counts were made by the method described by Pelroy and Eklund (1966). Briefly, the method is as follows: 45 g of excised fish flesh is homogenized aseptically with 180 ml of sterile 0.1 percent peptone solution at 3.0°C (38°F). Serial dilutions in 0.1 percent peptone water were prepared for pour plates from the homogenate. Plate counts were made using TPY solution (1.5 percent trypticase, 0.5 percent peptone, 0.5 percent yeast extract, 0.2 percent glucose, 0.5 percent NaCl, and 1.5 percent agar). Plates were incubated at 22°C (72°F) for 5 days.

The pH of the flesh of the salmon was measured by homogenizing at 4:1 mixture by weight of distilled water and fish

flesh. A Corning combination electrode was used to make the measurement.

Analysis of CO₂ content in the flesh of the salmon was made by the following method: A sample of flesh was blended in an alkaline (pH 10.4) Tris buffer (0.05 M), and then treated with an acid buffer to liberate CO₂. Concentrations were read from a calibration curve prepared from millivolt (Mv) readings obtained with an Orion carbon dioxide electrode connected to an Orion model 801 pH meter.

The salmon were chemically tested for oxidative rancidity (TBA number) using the method described by Lemon (1975). Essentially, the procedure calls for blending tissue in an extracting solution (trichloroacetic acid, propyl gallate, and EDTA) and filtering. The filtrate is reacted with TBA reagent and boiled. The cooled sample is read spectrophotometrically.

Sensory Tests

At each sampling, the raw salmon were judged for appearance, texture (as determined by finger pressure), odor, and color of the flesh. The salmon were prepared for sensory evaluation by baking in covered aluminum containers for 15 minutes at 350°F. The samples were evaluated by a five-member taste panel for flavor, texture, and rancidity using a 5-point numerical scale. A score of 2 or below for the sensory criteria indicates a product of unacceptable quality. Canned salmon was evaluated for fill weight, vacuum, color, and general appearance and acceptability.

Results and Discussions

Bacteriological Measurements

Results of the bacteriological examinations are shown in Table 1. Total bacterial counts made on the fish held in the MA remained low for the full 21 days of the test. The results show that the counts never exceeded 10⁴ organisms/g, which is normal for very fresh fish. A total bacterial plate count of 10⁶ organisms/g is generally considered indicative of incipient spoilage. In a similar study, Parkin (1979) reported essentially no growth of aerobic bacteria on rockfish filets stored refrigerated in an atmos-

Table 1.—Microbiological and chemical changes occurring in the flesh from butchered salmon held in a refrigerated, controlled atmosphere.

Storage time (days) ¹	Chemical Data			Total bacterial counts (no./g)
	pH	CO ₂ Conc. (ppm)	TBA (μ M/100g)	
0	6.22	247	0.25	2.8 × 10 ⁴
6	6.23	760	0.23	4.2 × 10 ⁴
10	6.23	687	0.67	1.0 × 10 ⁴
15	6.11	817	0.44	1.3 × 10 ⁴
20	6.20	1,118		3.4 × 10 ⁴
21	6.22	913	0.64	2.0 × 10 ⁴

¹Storage time given is the number of days held at the laboratory.

phere containing 80 percent CO₂/20 percent O₂ for 14 days. Similar observations were made by Barnett et al. (1971) on whole yellowtail rockfish and chum salmon, *Oncorhynchus keta*, held in refrigerated seawater modified with CO₂. King and Nagel (1975) in studies on *Pseudomonas aeruginosa* suggested inhibition of microbial growth by CO₂ is "in part due to a mass action effect on certain decarboxylating enzymes" which interferes with metabolic pathways essential for normal growth. *Pseudomonas* spp. bacteria are generally associated with spoilage of fresh fish and are controlled by the presence of as little as 5 percent CO₂ in the CA (Coyne, 1933).

Chemical Measurements

pH

The pH values of the salmon (Table 1) did not change significantly from their normal (initial) physiological pH during the test. Small differences are attributed more to biological variation among the fish than to the effects of the CO₂. However, Makashev (1959) observed a two-fold increase in the acidity (pH) of fish muscle stored in a CO₂ environment. The pH of rockfish filets (Parkin, 1979) decreased from about 6.7 to 6.3 after 1 week in a MA containing 80 percent CO₂. It is assumed that the pH of the salmon in this experiment did not become more acid because of the strong buffering capacity of the flesh or other physiological conditions existing during the experiment. The pH of the flesh of the fish would be expected to increase (become alkaline) if normal bacterial spoilage had occurred.

CO₂ Concentration

As shown in Table 1, the concentration of CO₂ found in the muscle of the MA-stored fish increased by a factor of about 5 during the experiment. The largest increase occurred between the first and fifth days of storage. A similar phenomenon was observed by Barnett et al.

(1971, 1978) in experiments with use of CO₂ in refrigerated brine for preservation of fish and shellfish. The increase is partly due to a complexing of the CO₂ with muscle protein and/or combining with physiological electrolytes.

TBA Measurements

As indicated by the relatively low TBA

values (Table 1), oxidation of lipids in the flesh of the salmon, because of exposure to a high concentration of CO₂, was not a significant factor in this experiment. This is attributed to the relatively low concentration of O₂ in the MA environment and also to the low-storage temperature. CO₂ is known to retard oxidation of fats (Makashev, 1959) at low concentrations (20-30 percent) and is apparently more effective at higher concentrations (Tarr, 1948).

Table 2.—Sensory evaluations of butchered salmon held in a refrigerated CO₂-modified atmosphere.

Storage time (days)	Average sensory scores ¹ on baked salmon samples			General comments on raw salmon
	Flavor	Texture	Rancidity	
0	4.2 ± 0.8	4.6 ± 0.5	5.0 ± 0	Fish are mature but of excellent quality
6	4.0 ± 0.7	4.2 ± 0.4	4.6 ± 0.5	Good color, odor, and texture
10	4.3 ± 0.8	4.4 ± 0.9	4.5 ± 0.4	Very good quality
15	4.2 ± 1.6	4.4 ± 0.8	4.6 ± 0.7	Normal color, odor, firm texture
19	3.0 ± 1.1	4.4 ± 0.5	4.6 ± 0.6	Slight oily odor, good color, firm texture
21	3.7 ± 1.6	4.7 ± 0.5	4.4 ± 1.6	Slight oily odor, good color, and texture; fish are of acceptable quality

¹Scores are based on a 5-point numerical scale: Score of 2 denotes a product of borderline quality.

Table 3.—Physical and sensory evaluations of canned salmon prepared from salmon held in a refrigerated, CO₂-modified atmosphere.

Days of storage	Code ¹	Net Weight (oz.)		Vacuum (in.)		Color	Remarks
		Range	Avg.	Range	Avg.		
0	(MDS)	7.6-8.5	7.9	1.0- 7.0	5.2	Avg.	Very slight oily flavor, slight curd, and normal texture
6	(BC)	7.7-8.4	8.0	0 - 5.0	3.5	Avg. (+)	Normal flavor, odor, and texture Normal flavor, muddy odor, slight soft texture and water marked (acceptable)
	(DS)	8.0-8.4	8.3	1.0-10.0	6.5	Avg. (-)	
10	(BC)	7.5-8.4	7.9	0-14.0	8.0	Avg.	Normal flavor, odor, and texture; moderate curd Typical flavor and odor for water-marked fish; slightly soft with moderate curd (acceptable)
	(DS)	8.0	8.0	8.0	8.0	Avg. (-)	
14	(DC)	7.6-8.2	7.9	8.0-10.0	9.0	Avg.	Normal odor, flavor, and texture for water-marked fish; moderate curd (acceptable) Normal odor, flavor; slight soft texture; moderate curd
	(DS)	7.5-7.7	7.6	8.0-10.0	9.0	Avg.	
19	(BS)	7.3-8.1	7.8	6.0- 8.0	7.0	Avg.	Normal odor; moderate, oily flavor and normal texture; moderate curd Normal odor and flavor for water-marked fish; slight, soft texture; moderate curd (acceptable)
	(DC)	7.2-8.1	7.7	6.0-12.0	8.5	Avg.	
21	(DS)	7.6-8.0	7.7	8.0- 9.0	8.5	Avg. (-)	Slight oily odor and flavor; normal texture; moderate curd Normal flavor and odor; normal texture; moderate curd
	(BC)	7.3-8.2	7.8	7.0- 8.0	7.7	Avg.	

¹MDS = medium dark silver.
BC = bright chum.
DS = dark silver.
BS = bright silver.

Sensory Evaluations

The salmon from the MA storage were examined periodically for sensory changes. Samples were evaluated raw, cooked, and canned.

Raw Salmon

No serious deterioration of overall quality was observed in the fish during the experiment (Table 2). In studies using CO₂ to preserve fresh sole and cod, Coyne (1933) found that the texture of the fish was slightly softer after prolonged storage in a high concentration (100 percent) of CO₂ than fish exposed to CO₂ concentrations of 40-60 percent. We did not observe subjectively any significant softening of texture in this experiment.

Cooked Salmon

Flavor scores generally indicate that the MA-held fish, irrespective of species, remained of acceptable quality for the duration of the test (Table 2). No significant differences (*P* 0.05) were found in the flavor and texture between the initial, untreated fish, and those held in the MA for 21 days. There was no significant difference in the organoleptic rancidity scores between the untreated fish and the fish held in MA. The sensory scores also indicate that the texture of the salmon was not adversely affected by exposure to the MA. Sensory examinations for rancidity correlated well with chemical tests for rancidity.

Canned Salmon

Canned salmon were evaluated for fill weight, vacuum, color, and general appearance and acceptability (Table 3). Net weights varied as a result of difficulty

in filling each can by hand using estimated in-fill weights. The occasional loss of vacuum in the cans was caused by over-filling with product. None of the canned product examined was considered spoiled or was rejected on the basis of decomposition. Low marks were mainly given on the basis of the maturity of the fish, i.e., water marked, muddy odor, texture and curd defects, and oily flavor.

Some swelling of the air-cooled cans was noted; but after several days in storage, the swelling subsided. The swelling of the cans was caused by excess (free) CO₂ liberated from the flesh during the cook, which resulted in occasional buckling of cans. Increasing the vacuum (24 inches) cycle of the can seamer by about 15 seconds prior to closing and a slow release of pressure from the retort after the cook helped to control the problem. Icing and holding the fish overnight prior to canning had no effect on resolving the excess CO₂ and the buckling problem.

Refrigerated Shelf-Life Test

After 2 weeks in the MA environment, 6 butchered salmon were individually packaged in polyethylene bags and stored in a 2°C (35°F) refrigerated room until organoleptically spoiled. The fish were periodically examined and evaluated for odor, color, and general appearance. They retained most of their good quality up to the fourth day of the test when a slight off-odor not associated with spoilage was detected. The odor was not detected after the fish were washed. No other significant changes were noted in the fish samples until the seventh day of storage. At this time, the remaining samples had a distinct sour odor on the skin, in the flesh, and in the poke (belly cavity). Significant discoloration of the peritoneal lining (not the underlying flesh) of the belly cavity was also observed. The samples were considered organoleptically unacceptable. At this time, the fish had been out of water about 23 days.

Summary and Recommendations

The results of the experiment described here show that fresh, butchered salmon can be bulk-held in acceptable condition for up to 21 days at 0°C (32°F) in a MA containing 90 percent CO₂. Butchered salmon usually spoil within 12 days on ice.

The effect of the CO₂ was to slow the growth of spoilage bacteria apparently by an inhibition of the CO₂ on specific metabolic pathways involved in the normal growth of the bacteria. It also appeared that the combination of low O₂ and high CO₂ concentration in the preservative gas protected the salmon from the effects of oxidative rancidity.

Retention of excess CO₂ in the flesh of the salmon caused some swelling in the canned product. This condition was the result of "free" CO₂ liberated during the cook. After cooling, swelling of the cans was not evident. Sensory evaluation of the canned product showed it to be normal in appearance, odor, color, flavor, and texture for canned mature, net-caught salmon. For commercial application in canning salmon of different quality or species, additional tests should be conducted.

Salmon removed after 2 weeks in MA storage and held on ice in a refrigerated room remained of acceptable quality for almost 1 week.

The MA preservation method described here can be considered for commercial use. It is recommended, however, that each user initiate shipments on a small scale to gain familiarity and experience with the technique and its special handling requirements. Above all, salmon to be shipped and marketed as fresh via this method should be of the highest quality. Furthermore, they should be thoroughly washed and prechilled prior to containerization. The temperature of the fish should be maintained at 0° ± 0.5°C (32° ± 1°F) at all times when in transit.

Because of the preliminary nature of the work described here, it is recommended that additional research be

conducted to further evaluate the preservative effects of CO₂ and other atmospheres with respect to different fish species. The public health significance is important in using processes in which the normal microbiological spoilage pattern is modified as in the MA environment. The possible presence of *Clostridium botulinum* and its ability to grow and develop toxin in the CO₂ MA at higher (abuse) temperatures require that future research include studies and recommendations for insuring product safety during distribution and marketing.

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Microbiological Profile of Pacific Shrimp, *Pandalus jordani*, Stowed Under Refrigerated Seawater Spray

J. S. LEE and EDWARD KOLBE

Introduction

Mechanically refrigerated seawater spray (RSWS) has replaced the traditionally used ice to chill shrimp on some Pacific Northwest fishing vessels. The perceived advantages of this system seem to meet the needs of the time. It eliminates dependence on sometimes scarce and costly ice, it results in savings on fuel cost for hauling the ice, and it reduces the labor cost needed to mix the shrimp and ice.

Seawater composition can be easily modified and the shrimp may be super-chilled to below 0°C in seawater. Roach and Harrison (1954) increased the NaCl concentration to 6 percent, and obtained firmer and more readily peelable shrimp. Seagran et al. (1960) gained 1-2 additional days of storage life by storing pink shrimp at -1.1°C (30°F) instead of at the melting ice temperature of 0°C (32°F). Nelson and Barnett (1973) advocated the addition of CO₂ in seawater for bacteriostatic purposes. Ruello (1974) reported that, in addition to being bacteriostatic, the added CO₂ acidified the seawater and inhibited the black spot development in Australian prawn, *Penaeus plebejus*.

To realize these potentials, however, the system has to overcome several limitations. One of these is its inherent characteristic of exposing the entire content of the fish hold to a common environment of recirculating seawater. Any "hot spot" or poorly refrigerated section of the hold will eventually affect the entire catch. Additionally, new catches of unchilled shrimp will continually be added during the trip, each time creating a temperature fluctuation. Adequate design procedures must be followed to minimize these effects. Kolbe (1979a, 1980) has described shrimp cooling characteristics and workable sprayer designs. In a companion paper, Kolbe (1979b) described a RSWS system design model that can be used to select adequate compressor capacities, chiller performance, and other operating parameters.

Optimum performance of the RSWS system, however, cannot by itself assure

high quality of stowed shrimp. The RSWS may become contaminated from an unclean fish hold or from the shrimp itself. The effect of these factors on the ultimate microbial quality of RSWS shrimp is largely unknown.

To answer these questions, we isolated and identified microorganisms from both shrimp and seawater samples taken from two RSWS boats during actual fishing conditions. We also employed a self-contained RSWS unit to conduct two controlled experiments, one onboard a fishing vessel, a second onshore. This paper describes our findings.

Materials and Methods

Sampling

Shrimp and refrigerated seawater (RSW) samples were collected on four occasions. Two of these samples were obtained onboard fishing vessels with RSWS systems. Additional samples were obtained from a self-contained RSWS apparatus installed onboard a research vessel, and on another occasion with the apparatus operated onshore. These experimental conditions are described in more detail below.

J. S. Lee and Edward Kolbe are with the Department of Food Science and Department of Agricultural Engineering, Oregon State University, Corvallis, OR 97331. This article is Technical Paper No. 5757, Oregon Agricultural Experiment Station, Corvallis.

ABSTRACT—Microbial counts of refrigerated seawater, which held shrimp at -1.1°C (30°F) for 3 days, ranged from 8.0×10^3 to 1.5×10^6 per ml depending on the systems we examined. Although *Flavobacterium-Cytophaga* sp. predominated the microbial flora of initial seawater (46 percent), the microbial population in subsequently

refrigerated seawater was dominated by *Moraxella* sp. (96 percent) in one instance and *Pseudomonas* sp. (88 percent) in another. *Moraxella* sp. were the most difficult to eliminate on the fishing vessels, and poorly washed shrimp tended to yield more *Arthrobacter* sp.

Most microorganisms grew poorly in chilled seawater, with the exception of *Pseu-*

domonas sp. Therefore, the initial microbial load of the system or of the shrimp, tended to play a greater role in determining the microbial quality of the stowed shrimp than the growth of microorganisms in chilled seawater.

Under optimum conditions, refrigerated seawater spray can maintain the freshness of the shrimp for 5 days.

Table 1.—Microbial count of RSW samples from RSWS boat trip 1.

Sample no. ¹	Time	Microbial count per ml or g
RSW 1	0730, Day 1	7.7×10^4
2	1230, Day 1	8.9×10^4
3	1800, Day 1	9.6×10^4
4	0655, Day 2	5.3×10^5
5	1205, Day 2	3.4×10^5
6	2150, Day 2	3.0×10^6
7	0705, Day 3	7.6×10^5
8	2100, Day 3	1.5×10^6
Shrimp ³ 1	1530, Day 1	1.9×10^2
³ 2	1145, Day 3	1.7×10^4
³ 3	1650, Day 3	5.2×10^3

Fish hold ceiling scraping⁵ 0700, Day 1 4.5×10^6

¹See Figure 1.

²Microbial flora identified and presented in Table 4.

³Shrimp samples taken from sorting tables after seawater washing.

⁴Shrimp sample taken from fish hold 1 day after catch.

⁵After the hold had been cleaned and sanitized.

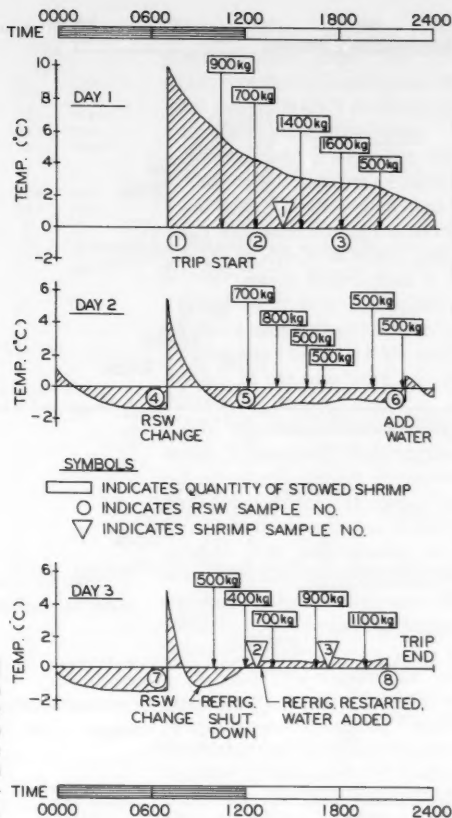


Figure 1.—Trip of RSWS boat 1 and sump temperature. The time and quantity of shrimp stowed, the RSW sample number, and shrimp sample number correspond to those in Table 1.

RSWS Boat 1

The concrete-lined fish hold of a 26 m (86 foot) shrimp trawler was brushed and sprayed with a commercial preparation of sodium hypochlorite solution. After this, about 1,100-1,500 l (300-400 gallons) of seawater containing 4 l of sodium hypochlorite was circulated for approximately 10 minutes. We were not able to determine the exact strength of the sodium hypochlorite solution used.

This boat's fishing trip is schematically presented in Figure 1. Seawater and shrimp samples were taken in sterile plastic bags and frozen immediately by placing on dry ice. After completion of the 3-day trip the samples were delivered

frozen to the laboratory for analysis. The sample numbers shown in Figure 1 correspond to those to Table 1.

The shrimp were thoroughly washed on deck with seawater to remove the bulk of mud and debris, hand sorted, and stowed in the fish hold.

The refrigeration capacity of this vessel appeared marginal. As shown in Figure 1 the spray water temperature which was 5.5°C (42°F) when loading the first batch of shrimp, did not reach below 2.2°C (36°F) for more than 10 hours. The operating temperature of -1.4°C (29.5°F) was reached overnight. Nevertheless, it reached above 4.4°C (40°F) whenever the seawater was changed (once each day). In a few cases, stowed

shrimp temperature increased above 4.4°C (40°F) when new shrimp were loaded on top.

The total catch for the trip was approximately 12,300 kg (27,000 pounds) of shrimp and about 230-370 kg (500-800 pounds) of groundfish.

RSWS Boat 2

The boat 2 fishing trip is illustrated in Figure 2, and the sample numbers here correspond to those in Table 2. The fish hold of this vessel was lined with fiberglass. The refrigeration system of boat 2 appeared slightly more powerful than that of boat 1 and the catch was smaller, with the 3 days total being 7,600 kg (17,000 pounds) of shrimp and 225 kg

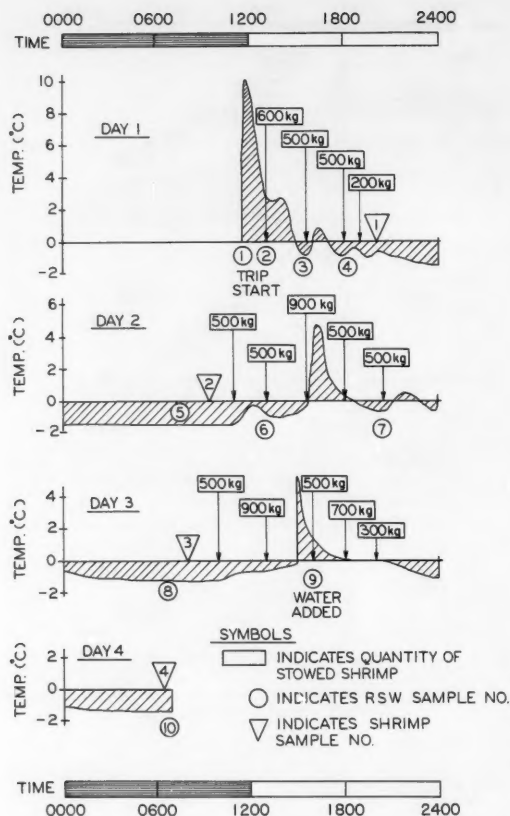


Figure 2.—Trip of RSWS boat 2 and sump temperature. The time and quantity of shrimp stowed, the RSW sample number, and shrimp sample number correspond to those in Table 2.

Table 2.—Microbial count of RSW samples from RSWS boat trip 2.

Sample no. ¹	Time	Microbial count per ml or g
RSW		
² 1	1130, Day 1	30
2	1250, Day 1	8.3×10^4
3	1420, Day 1	1.8×10^5
4	1755, Day 1	1.8×10^5
5	0710, Day 2	2.7×10^5
6	1250, Day 2	3.3×10^5
7	1955, Day 2	3.9×10^5
8	0700, Day 3	2.3×10^5
9	1510, Day 3	9.0×10^5
10	0645, Day 4	2.7×10^5
Shrimp		
³ 1	1950, Day 1	5.5×10^5
⁴ 2	0920, Day 2	1.0×10^5
⁵ 3	0740, Day 3	3.7×10^5
⁶ 4	0645, Day 4	4.9×10^5

¹See Figure 2.

²Seawater at intake.

³Microbial flora identified and presented in Table 4.

⁴Shrimp sample taken from sorting table on deck.

⁵Shrimp samples taken from fish hold.

(500 pounds) of groundfish. Thus RSW temperatures could be maintained at around -1.1°C (30°F) for a greater percentage of the time. On the other hand, the fishermen did not change the RSW during the trip and the shrimp were not washed thoroughly before stowing. The spray coverage was not uniform and the temperature probes placed throughout the hold area revealed several hot spots of 1.7°C (35°F) or above. An iodophor solution of again unknown strength had been circulated through the spray system before filling the sump with fresh seawater.

Sea Trial of Model RSWS Unit

We used a self-contained RSWS unit¹ consisting of a fiberglass insulated tank having dimensions of $1.22 \times 0.61 \times 0.76$ m ($4 \times 2 \times 2.5$ feet) and a refrigeration unit connected to it.

The unit was cleaned thoroughly with a stiff brush, and later Wisk², a liquid

household detergent, was circulated for 30 minutes. After draining, the system was flushed with fresh water. Then a 50 ppm sodium hypochlorite solution prepared from a household bleach was circulated for 30 minutes, after which the tank was drained and allowed to dry overnight. This cleaning and sanitizing regime had been previously tested and found to be effective (Kolbe and Lee, 1980).

The refrigeration unit effectively maintained the RSW temperature at -1.1°C (30°F). The intersecting spray, large droplet nozzles (Bete Fog Nozzle, Inc., Greenfield, Mass.) provided a uniform spray coverage at an average density of 38 l/minute per m^2 (0.94 gpm/foot²).

¹This apparatus was loaned by the Utilization Research Division, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, 2725 Montlake Blvd. East, Seattle, WA 98105.

²Mention of trade names or commercial firms does not imply endorsement by the authors or by the National Marine Fisheries Service, NOAA.

Table 3.—Contact plate count of fish hold surfaces of RSWS boats awaiting departures.

Boat	Site ¹	Microbial count/cm ²	
		1200 h	1800 h ²
Boat 1	1	TNTC ³	TNTC
	2	51	155
	3	71	>160
	4	28	43
Boat 2	1	14	—
	2	61	—
	3	70	—
	4	>160	—
	5	135	—

¹All were from ceiling reached through hatch covers.

²Cancelled trip of boat 1 offered second sampling opportunity.

³TNTC = too numerous to count.

Table 4.—Microbial flora of seawater and RSW.

Micro-organism (%)	Sea-water ¹	RSW ² of boat 1		RSW of boat 2	
		New	Old	New	Old
<i>Pseudomonas</i>	2.4	6.2	5.2	10.3	5.4
<i>Moraxella</i>	0	64.6	79.3	38.5	50.0
<i>Acinetobacter</i>	2.4	4.6	0	5.1	6.8
<i>Flavobacterium</i>					
<i>Cytophaga</i>	46.3	16.9	9.5	21.8	16.2
<i>Arthrobacter</i>	24.4	1.5	4.3	23.1	20.3
<i>Lactobacillus</i>	0	0	0.9	0	0
<i>Micrococcus</i>	0	0	0	0	1.4
Unidentified	24.9	6.2	0.9	1.3	0
No. colonies identified	41	65	116	78	74
Count of sample/ml	23	7.7×10 ⁴	1.5×10 ⁶	8.3×10 ⁴	7.3×10 ⁵

¹Fresh seawater at intake.

²New RSW was at the start of the trip before any shrimp was put down. Old RSW was at the end of 3-day trip.

³Resembled *Aerococcus*.

The 270 kg (600 pounds) of shrimp were put down at the beginning of the trip. This model unit had an efficient straining system and contained no bin board.

Shore Trial of Model RSW System

The self-contained unit described above was installed onshore to extend the holding period beyond the customary 3 days. The unit was cleaned and sanitized as described previously, then filled with a 3.5 percent solution of rock salt and chilled to -1.1°C (30°F). A 180 kg (400 pound) load of freshly caught shrimp was placed in plastic containers, kept chilled onboard a fishing vessel and delivered and placed immediately in the unit. The shrimp was out of water for approximately 5.5 hours by that time. We then operated the unit continuously for 7 days and took periodic samples of RSW and shrimp.

Tests

Temperature

A YSI telethermometer Model 42 with 6 thermister probes (Yellow Springs Instrument Co., Yellow Springs, Ohio) was used to monitor temperatures in various parts of the fish hold and within the experimental unit. The instrument with probes is claimed by the manufacturer to have an absolute accuracy of ±0.6°C

(±1°F), a reproducibility of ±0.6°C (±1°F), and a time constant of 7 seconds.

NaCl

The NaCl content in Cl⁻ concentration, was measured with a Quantab test strip (Ames Co., Elkhart, Ind.).

pH

A Beckman Zeromatic II pH meter was used for pH measurement of RSW samples.

Microbial Count

Microbial number was counted by spread-plating the appropriate dilutions in 0.067 M phosphate buffer, on tryptone-peptone-yeast extract (TPE) agar and incubating aerobically at 25°C for 48-72 hours (Lee and Harward, 1970).

Microbial Identification

The replica-plating scheme was used to identify bacteria to the genus level (Lee and Pfeifer, 1975).

Results and Discussion

Microbial Counts of RSW Obtained at Sea

As described, two trips onboard the RSWS shrimp boats are illustrated in Figures 1 and 2. The temperature of RSW in the sump, monitored continu-

ously during the entire trip, is superimposed on each graph. The time and quantity of shrimp loadings and the time when either the RSW or shrimp samples were taken, are also indicated.

Tables 1 and 2 show the microbial counts of the samples obtained from these trips. The microbial load of seawater measured during the second trip was 30/ml but it increased quickly to 7.7×10⁴/ml in RSWS boat 1 and to 8.3×10⁴/ml in boat 2 even before the shrimp was introduced to the system. The counts of the final RSW samples at the end of the trips were 1.5×10⁶ and 7.3×10⁵/ml, respectively.

The increase in counts of approximately 10 times in RSW during the 3-day trip was much smaller compared with the sudden increase in counts from 10¹ to 10⁴ when seawater was initially recirculated. The recirculating seawater seemed to have been quickly contaminated by inadequately cleaned fish hold surfaces, debris remaining in pipes, and wooden bin boards.

In a separate experiment, we took contact plate counts of fish hold surfaces of the two boats awaiting departure in the harbor and the results are presented in Table 3. The variety of cleaning procedures intended to reduce the initial microbial loading of RSW had not been successful. We found the foam-type detergent effectively cleaned the smooth surfaces, but cleaning inside the pipes and the wooden bin board were next to impossible. Our recommendation for proper RSW system construction, therefore, placed a greater emphasis on construction materials, a piping system having a minimum of dead ends, and the installation of a cleaning loop as previously recommended by Canadian investigators (Gibbard and Roach, 1976; Kolbe and Lee, 1980).

Microbial Growth in RSW During 3-Day Trips

Microbiological data from two trips onboard fishing vessels are summarized in Table 4. As noted, the RSW microbial count did not increase to more than tenfold after 3 days for either boat 1 or 2. This similarity is remarkable if one considers the differences in boat construc-

tion, the load of shrimp stowed, and the contrasting RSW operations. Boat 1 fish hold was constructed with concrete lining, the refrigeration capacity was marginal, and it carried a greater load of shrimp. At the same time, the shrimp was cleaned more thoroughly and the RSW was changed daily. Boat 2 had a smooth fiberglass-lined fish hold, had a greater refrigeration capacity, and did not land a large load of shrimp. On the other hand, the shrimp was not cleaned thoroughly before being placed in RSWs, and the water was not changed during the entire trip.

Table 4 also shows the identities of microorganisms isolated from RSW at the beginning of the trip, before shrimp had been put down, and those from RSW at the end of the trip. In both boats the microbial flora compositions of the new and the old RSW samples were remarkably similar. This indicated perhaps that the microorganisms initially present had equal selective advantages in the RSW or on the shrimp. Little change in microbial flora of RSW in 3 days could also indicate that, despite shortcomings, the microbial growth was kept to a minimum in both RSW systems.

Moraxella sp. that predominated the microbial flora of the RSW of boat 1 could have come from the unclean fish hold. We observed that the wooden bin boards yielded nearly a pure culture of *Moraxella* sp. even after being dried in the sun. The *Arthrobacter* sp. found in large proportions from boat 2 RSW could have come from the muddy shrimp. This microorganism of soil origin was more numerous in shrimp reared in earthen ponds (Vanderzant et al., 1970).

Microbial Characteristics of RSW Obtained From A Model System Installed on Fishing Vessel

Microbial counts, as well as the identities of those isolated during a holding trial of shrimp in RSW, are presented in Table 5.

This sea trial was conducted to evaluate the performance of a RSW system under controlled conditions. The fiberglass-lined tank did not require bin boards. Shrimp was put down only once

Microorganism (%)	RSW sample intervals (hours)								Shrimp (hours)	
	6	1	13	24	37	47	58	68	2	68
<i>Pseudomonas</i>	0	12.3	42.7	31.6	76.1	79.8	87.5	70.9	5.8	12.5
<i>Moraxella</i>	0	10.5	6.1	17.1	7.0	4.0	1.4	10.4	0	0
<i>Acinetobacter</i>	0	5.3	7.3	11.8	4.2	8.1	1.4	4.2	2.9	0
<i>Flavobacterium-Cytophaga</i>	0	7.0	3.7	7.9	2.8	4.0	0	4.2	2.9	9.4
<i>Bacillus</i>	0	3.5	0	1.3	0	0	1.4	0	14.7	6.3
<i>Arthrobacter</i>	100	40.4	24.4	13.2	7.0	0	5.6	2.1	35.3	46.9
<i>Staphylococcus</i>	0	3.5	11.0	9.2	0	1.0	0	2.1	2.9	3.1
<i>Micrococcus</i>	0	5.3	2.4	3.9	2.8	0	0	0	17.7	21.9
Others ³	0	12.3	2.4	3.9	0	0	2.8	4.2	17.7	0
No. colonies identified ⁴	5	57	82	76	71	99	72	48	34	32
Count of sample/ml or g	2	230	430	540	960	1,200	1,300	800	1,700	2,100

¹RSW chilled to -1.1°C and recirculated for 10 hours before shrimp was put down.

²Shrimp as landed.

³Others include 10.5 percent yeast for 11 hours RSW but the rest were unidentifiable.

⁴All isolated colonies on agar plates were picked for identification.

at the beginning of the experiment. The spray pattern and chilling rate were controlled to maintain a constant -1.1°C (30°F). The water, however, was not changed during the 3-day holding experiment.

We also tested, with this unit, our recommended cleaning and sanitizing procedures of brush-cleaning with a liquid household detergent and recirculating 50 ppm chlorine, prepared from a household bleach, for 30 minutes (Kolbe and Lee, 1980).

The RSWS system, before introduction of shrimp, was nearly free of bacteria. The count of RSW before shrimp addition was 2/ml of *Arthrobacter* in pure culture. Limited deck space did not allow us to clean the shrimp as thoroughly as we wanted. This perhaps was reflected in the higher proportions of *Arthrobacter* sp. in earlier RSW samples.

The data however, showed a steady increase in *Pseudomonas* population. The initial RSW, after shrimp addition, contained 12 percent *Pseudomonas* sp. with 40 percent *Arthrobacter* sp. During the 68-hour holding period, the proportion of *Pseudomonas* sp. steadily increased to 80 percent of the total. The genus *Pseudomonas* contains many species known to contribute to fish spoilage (Liston, 1980). Therefore, this shift in microbial population of RSW appears

significant, despite the limited increase in the microbial number, from 230 to approximately 1,000/g in 68 hours.

The microbial count of shrimp remained near 2,000/g throughout, and the population shift was not as noticeable as in RSW.

Other than the aforementioned population shift, the types of microorganisms isolated from RSW and RSW shrimp were those commonly found in seafoods (Lee and Pfeifer, 1977; Liston, 1980). An exception was the presence of staphylococci, which were not detected in RSW samples obtained under more aseptic conditions. Thus, they could have been introduced during sampling.

The Model RSWS System Operated Onshore

Microbial number, pH, NaCl concentration of refrigerated 3.5 percent NaCl solution, and the microbial count of the shrimp placed in it, were monitored for 7 days (Table 6).

The microbial count of the shrimp was $9.1 \times 10^5/\text{g}$ before being placed in the RSWS system. It remained at the same or lower level for 7 days in the saltwater solution kept at a constant -1.1°C . The microbial flora of the shrimp consisted almost exclusively of *Moraxella* sp. and, surprisingly, no *Pseudomonas* sp. was found.

Table 6.—Microbial profile of 7-day trial on model RSWS unit operated onshore.

Time of sampling (hours)		Microbial count		RSW		Moraxella (%) of shrimp flora
RSW	Shrimp	RSW per ml	Shrimp per g	pH	NaCl(%)	
1-1	1-1	>30	9.1×10 ⁵	7.2	3.2	— ²
18 (day 1)	18	7.1×10 ⁴	5.2×10 ⁵	7.9	3.4	93
42 (day 2)	42	4.4×10 ⁴	3.5×10 ⁵	8.1	2.7	83
60 (day 3)	60	9.7×10 ⁴	1.8×10 ⁵	8.2	2.5	92
88 (day 4)	88	1.2×10 ⁵	8.0×10 ⁴	8.1	2.6	94
101 (day 5)	101	2.1×10 ⁵	1.2×10 ⁵	8.1	2.3	79
136 (day 6)	136	1.3×10 ⁵	2.1×10 ⁵	8.1	2.1	96
150 (day 7)	153	2.4×10 ⁵	2.9×10 ⁵	8.0	2.1	96
						95

¹RSW, before shrimp addition, and shrimp, before being placed in RSWS system.²Not done.³The remaining microorganisms belonged to *Arthrobacter*, *Acinetobacter*, and *Flavobacterium-Cytophaga* sp. No *Pseudomonas* sp. was isolated.⁴Shrimp began to show deterioration.

The microbial load of the simulated RSW increased quickly to 7.1×10⁴/ml upon addition of shrimp, but, beyond that, it did not increase noticeably in 7 days. The pH of the RSW increased gradually from 7.2 to 8.0 and the NaCl concentration decreased slowly to 2.1 percent during the same time period.

The RSWS system was set up onshore to test the system beyond 3 days. But this also created the logistical problem of transferring shrimp from the vessel to the system. The shrimp, although held in plastic containers which were stored in a cool environment, were still 5.5 hours out of water. The shore facility did allow us to exercise more care in sampling. The ratio of water to shrimp turned out to be higher (nearly 1:2) than was typically found on shrimp vessels (boat 2 had an estimated ratio close to 1:5).

These differences and, above all, the serendipitous elimination of *Pseudomonas* sp. could have yielded such remarkable performance data for RSWS. Despite the low microbial level, however,

the shrimp began to look bleached, soft, and showed various signs of deterioration on the 5th day. Their appearance was at the borderline of acceptability on the 7th day.

The microbial counts as well as the compositions of the microbial population were quite different for the four different RSWS systems investigated. These differences, however, were easily attributable to the different operation conditions. The data, nevertheless, clearly pointed out that the RSWS system, when properly operated, can effectively control the growth of microorganisms in shrimp, and that the initial microbiological conditions of the shrimp or RSW will determine the ultimate microbiological quality of the RSWS held shrimp.

Acknowledgments

This work is a result of research supported in part by Oregon State University Sea Grant College Program, supported by NOAA's Office of Sea Grant, U.S. De-

partment of Commerce, under Grant No. NA79AA-D-00106. We thank Captains L. Kuntz and M. Wheeler for their cooperation and D. Cheney and D. Pfeifer for technical assistance.

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Tagging Herring With Coded-wire Microtags

KENNETH J. KRIEGER

Introduction

An efficient method of marking large numbers of herring, *Clupea harengus*, has application in separating stocks, describing seasonal migration, and estimating abundance of populations. Herring have been marked with a variety of external and internal tags. External tags of plastic or metal have been attached to fins, opercula, or muscle; internal tags of magnetized metal (Dahlgren, 1936) or radioactive metal (Wilimovsky, 1963)

ABSTRACT—A coded-wire microtag system can be used to tag Pacific herring, *Clupea harengus pallasii*. Adult herring were tagged in the geniohyoideus muscle and held for 13 months. Of the 136 fish tagged, 81 percent survived; 98 percent of the survivors retained tags. During shipboard experiments, an average of 10 fish were tagged per minute.

have been placed in body cavities.

Coded-wire microtags, used to mark young salmon, can also be used to mark herring if the appropriate technique is followed. The tag—a 6-bit, binary-coded wire of stainless steel—is small (0.254 mm diameter, 1.07 mm long) yet allows coding for 262,144 number combinations. The microtag does not internally damage the fish or alter its external appearance.

Equipment and Methods

I used the coded-wire microtag system manufactured by Northwest Marine Technology (NMT)¹. The equipment includes a tag injector, a quality-control unit that magnetizes the tag and detects

untagged fish, a portable tag detector, and an AC-DC power supply².

When the tag injector is triggered, a hollow needle penetrates the fish; tagging wire is fed through the needle and cut; and the needle retracts leaving the wire tag implanted. The placement of an adjustable aluminum base controls the distance the needle penetrates the fish. For tagging Pacific herring, *Clupea harengus pallasii*, the distance between the aluminum base and the tip of the needle is 1.5 mm (Fig. 1). The needle extends an additional 4.5 mm from the aluminum base when the injector is triggered (Fig. 2). The distance the tag projects through the needle is controlled by an adjustment on the tag injector. For tagging Pacific herring, the tag is implanted 2.0 mm from the head-mold base (Fig. 3).

For the tag location, I chose the geniohyoideus muscle, located on the lower jaw between the dentary bones and immediately below the tongue (Fig. 4). The

¹Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

²Northwest Marine Technology, 1978. Binary coded marine identification system. Northwest Marine Technology, Shaw Island, WA 98286, 8 p.

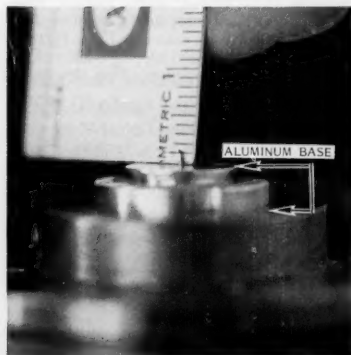


Figure 1.—Positioning of aluminum base to set needle length.

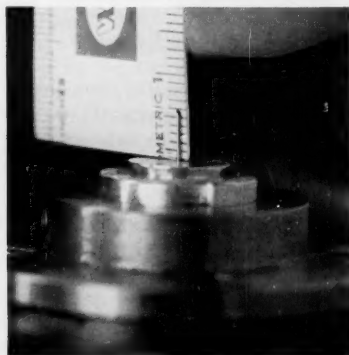


Figure 2.—Distance needle extended when machine is triggered.

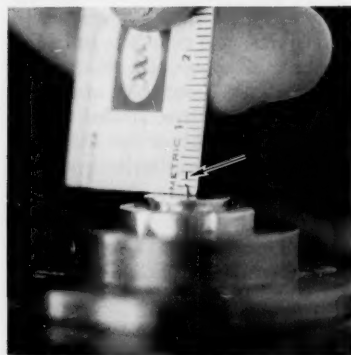


Figure 3.—Depth the tag is planted.

strong tissue of the geniohyoideus muscle prevents tag dislodgement yet is penetrable by the tagging needle. Tag placement is rapid and accurate, and the tag can be easily seen and removed from the clear geniohyoideus muscle.

To tag Pacific herring, the operator holds the fish ventral side up with the snout just below the tagging needle and pointing toward the aluminum base. While lifting the fish, the operator pushes the operculum slightly outward with the thumb. This motion allows the tagging needle to rest on the symphysis of the left and right dentary bones (Fig. 5). The fish is then tilted upward, and the operator triggers the injector with a foot switch.

The size of the fish determines the angle it is tilted. Large, adult Pacific herring (19-24 cm fork length) are tilted approximately 60° relative to the aluminum base (Fig. 6). At this angle, the tag is implanted directly behind the symphysis in the anterior geniohyoideus (Fig. 7). Juvenile and young-adult Pacific herring (11-18 cm fork length), which have a narrower muscle than adult fish, are tilted approximately 10° relative to the aluminum base (Fig. 8) to prevent the needle and tag from penetrating both sides of the muscle. At the 10° angle,

the tag is implanted in the posterior geniohyoideus muscle (Fig. 9).

The implanted tags are magnetized as the fish pass through the plastic tubes of the quality control unit. Fish with magnetized tags are then detected by a tag detector that senses changes in a magnetic field. The fish must move past the detector, or the detector past the

fish, at a minimum rate of 15-30 cm/second for changes in the magnetic field to be detected.

Retention of Tags

To determine tag retention and mortality from tagging, I tagged 136 adult Pacific herring on 5 November 1976 and held them in a circular tank 1.8 m high

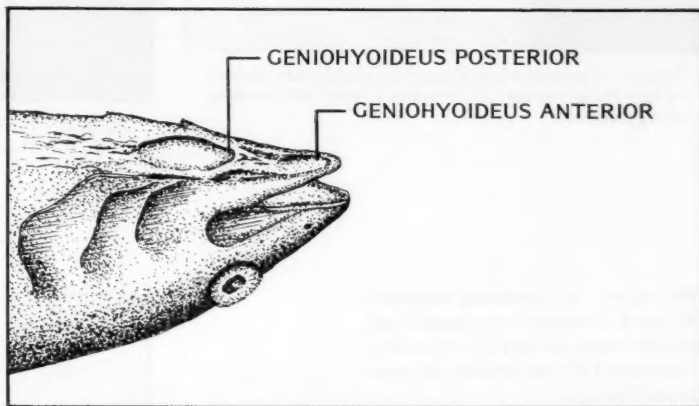


Figure 4.—Location of geniohyoideus muscle of Pacific herring.

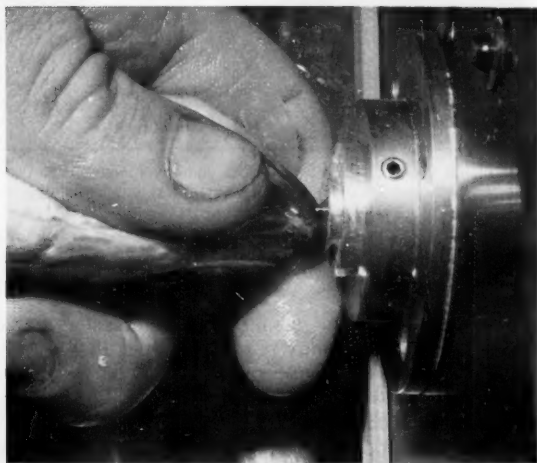


Figure 5.—Positioning of Pacific herring for tagging before tag injector is triggered.



Figure 6.—Position of large Pacific herring (19-24 cm fork length) when tag injector is triggered.

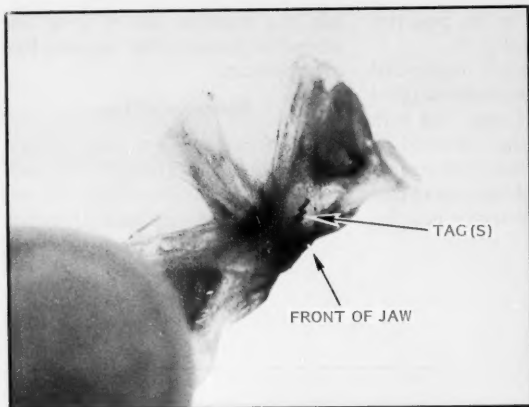


Figure 7.—Location of several tags in the geniohyoideus muscle of large Pacific herring (19–24 cm fork length). Note precision of tag placement.



Figure 8.—Position of small Pacific herring (11–18 cm fork length) when tag injector is triggered.

with 34,000 l of circulating seawater. Each week, dead fish were counted and checked for tags. At the end of the study, 5 December 1977, all surviving fish were checked for tags.

At the end of the study, 88 Pacific herring were alive, of which 86 (98 percent) contained tags. Of the original 136 tagged fish, 28 disappeared and could not be accounted for; 20 of the remaining 108 fish (19 percent) died between November 1976 and April 1977.

I checked 14 of the 20 dead fish and all 14 fish had tags. The dead fish had no infection where the tags were implanted, and I attributed their deaths to bacterial infection at scale-loss sites. Scale loss was heavy because the fish were repeatedly handled during their capture and transfer to the holding tank.

Field Tagging Study

Live Pacific herring were tagged aboard ship to develop tagging procedures and determine the rate of tagging under field conditions. On 16 November 1977, juvenile Pacific herring were captured with a midwater trawl in Fritz Cove, 13 km northwest of Juneau in southeastern Alaska, and placed into a holding tank aboard ship. The fish were not

anesthetized because low water temperature (5°C) minimized their activity. Fish were removed from the holding tank and placed in a bucket half-filled with seawater. The tagging operator then removed the fish from the bucket for tagging. Tagging speed was averaged from two 5-minute and two 10-minute

tagging periods. Two operators tagged an average of 10.6 and 10.0 fish per minute.

Tag Recovery

During experiments at sea, coded-wire microtags have been successfully detected in catches of Atlantic herring,

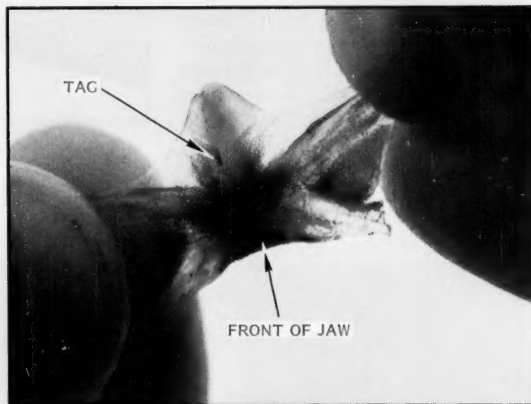


Figure 9.—Location of tag in the geniohyoideus muscle of small Pacific herring (11–18 cm fork length).

Clupea harengus harengus (Corten, 1980). These experiments were designed to determine the reliability and screening capacity of the detection equipment when it is used aboard vessels at sea. Nineteen microwire-tagged Atlantic herring were mixed with several hundred kilograms of unmarked Atlantic herring and fed into a NMT detector tube. All tagged fish were detected by the system, and no false alarms were registered. In a second test, one tagged Atlantic herring was placed among 100 kg of Atlantic herring, which were then placed in six baskets. The baskets were quickly emptied into the detector tube. The tagged

fish was detected (with no false alarms) during each of the several times the test was run. An average of 200 kg of fresh fish were screened per minute; 140 kg of fish with rigor mortis were screened per minute. Corten (1980) concluded that "the detection of magnetic coded wire tags in herring is very well possible" and "it is unlikely major problems will arise concerning the reliability of the detection system." Furthermore, he believed "the maximum throughput of fish with the present detector tube is already approaching the processing capacity of many commercial freezer trawlers."

Thus, it appears that the coded-wire

microtag system can be used to tag herring quickly and effectively with low tagging mortality and good tag retention (present study), and that tagged herring can be recovered from large catches (Corten, 1980).

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Gold, Silver Medals Given to Highest DOC Achievers

Gold medals were awarded by Commerce Department Deputy Secretary Wright to 17 Commerce employees—including two NMFS employees—in appropriate ceremonies in the Commerce Auditorium recently. Silver medals were awarded to 70 others.

Gold medals, the highest award given by the Department, are granted by the Secretary for rare and distinguished contributions of major significance to the Department, the nation, or the world. Silver medals are awarded for meritorious contributions of unusual value to the Department.

Gold medalists included:

Geoffrey C. Laurence, Supervisory Fishery Biologist, National Marine Fisheries Service, NOAA, who "has found some of the missing links of knowledge in the understanding of fish production in the ocean, the survival and growth of larval fishes."

John B. Pearce, Supervisory Fishery Biologist, National Marine Fisheries Service, NOAA, who "has planned, implemented, and/or directed two major programs in ocean monitoring—the Ocean Pulse Program for the Northeast Fisheries Center, and the Northeast Monitoring Program for NOAA."

Robert E. Joseph, Assistant Division Chief, and Paul R. Friday, Computer Systems Analyst, Technical Services Division, Census, "for their imaginative and innovative approach to the overall design" in creating a computer/peripheral network system "more sophisticated than that of similar systems throughout the world."

S. Thomas Romeo, Chief, Division of National Cargo, MarAd, "for his continued outstanding accomplishments in advancing and expanding the equitable

implementation of the cargo preference laws of the United States."

Burton H. Colvin, Director, Center for Applied Mathematics, NBS, "for his consistently outstanding management of the mathematics program at NBS."

Robert D. Cutkosky, Physicist, National Measurement Laboratory, NBS, "for providing leadership in research in the fields of electrical and temperature metrology."

J. William Gadzuk, Physicist, National Measurement Laboratory, NBS, "for his outstanding research in theoretical surface science" . . . and his "contributions to theories of surface properties and of the interaction of radiation with surfaces."

Ernest E. Hughes, Research Chemist, National Measurement Laboratory, NBS, "for his world leadership in the standardization of gas measurements."

Harry H. Ku, Chief, Statistical Engineering Division, NBS, "for his outstanding contributions in developing and applying statistical methods for maintaining international comparability of precision measurement experiments."

Theodore E. Madey, Physicist, National Measurement Laboratory, NBS, "for his forefront research and scientific leadership in extending the range and quality of surface-characterization methods."

William C. Martin, Physicist, Center for Radiation Research, NBS, "for his outstanding technical leadership of the NBS spectroscopy group, especially his accomplishment in directing an efficient transformation of this group into fundamentally new research areas to respond to changing needs."

John T. Yates, Jr., Research Chemist, National Measurement Laboratory, NBS,

"for his outstanding research and leadership in experimental surface science."

Donal G. Davis, Meteorologist, National Weather Service, NOAA, who was "directly responsible for and personally involved in issuing and disseminating tornado warnings and coordinating with local government safety officials" during a tornado emergency in Grand Island, Nebraska, 3 June 1980.

Diana H. Josephson, Acting Deputy Assistant Administrator for Satellites, NOAA, for "extraordinary contributions to the planning of the U.S. civil operational land remote sensing satellite activities."

Joseph Sela, Meteorologist, National Weather Service, NOAA, for his "major contribution to the operational forecasting capability of the National Meteorological Center by developing the recently implemented global forecast model."

Neal B. Seitz, Supervisory Electronics Engineer, NTIA, "for his research accomplishments in data communications performance requirements for users of communications systems."

Silver medals were awarded to 70 other individuals, including Andrew E. Dizon, Fishery Biologist, National Marine Fisheries Service, NOAA.

U.S. Seafood Exhibit Popular in Europe

The U.S. Seafood Exhibit at the 1981 ANUGA World Food Market Show held in Cologne, West Germany, in October, has been labeled a success by both industry and government participants. Seven United States fishery firms sold more than \$10 million in products participating in a Commerce Department seafood exhibition there, the Department reports. The food show alternates annually between Cologne and Paris where, last year, 22 U.S. companies sold only \$1 million in products, according to Commerce officials.

The 1981 exhibit was well organized and included an iced display of fresh fish and shellfish from across the United States. Industry participants reported a strong interest by foreign buyers and the sale of large quantities of their product.

A total of 918 sales leads were developed; 39 agreements were reached with agents to represent various firms and their products in Europe; and four joint venture agreements were signed in Cologne.

Quality Change in Frozen Pacific Whiting and in Minced Flesh

A study of the dimethylamine (DMA) content of frozen H&G (headed and gutted) Pacific whiting and frozen minced flesh during 6 months of storage at the NMFS Northwest and Alaska Fisheries Center has shown that the quality of the minced flesh is better if prepared from the H&G whiting during storage. The DMA content is the measure of the chemical degradation of trimethylamine oxide, a nonprotein nitrogenous constituent of the gadoid species. Other work has shown that increased levels of DMA in frozen fish correlate with decreased acceptability and losses in functional properties of the flesh. Inasmuch as minced fish will be most useful for production of processed food products such as fish cakes, sausages, and reformed products, the retention of high quality and functionality is most important.

The current study showed that if the minced flesh was prepared initially from fresh H&G whiting and frozen, the quality deterioration as measured by DMA content was far greater during subsequent storage than that observed in frozen H&G whiting. Furthermore, tests in which the minced flesh was prepared from H&G whiting after 4 months of 0°F indicated that, even if refrozen and held an additional month, the quality of the minced flesh was better than that prepared from the fresh or 1-month frozen whiting. This simple means that to protect the quality, it is better to store the whiting in the H&G form until shortly before the minced flesh is needed for production of the end product. These are preliminary tests and will continue with Pacific whiting and Alaska pollock because the full utilization of these resources can best be accomplished by use of the mechanically recovered

minced fish in various types of processed food products.

Jerry Babbitt and Barbara Koury

Alaska Pollock Nuggets Developed

Over 2,600 Alaska pollock nuggets were served by Jerry Babbitt and his research team at the Northwest and Alaska Fisheries Center's 1981 Open House on 23-24 October. The nuggets had been prepared and frozen ahead of time and were removed from the freezer and reheated to provide a hot fish snack for all visitors to the 4th floor exhibits of the Utilization Research Division. The recipe was adapted from the salmon nugget recipe of the Alaska Seafood Cookbook issued 30 years ago by the Ketchikan Fishery Products Laboratory. The 140 pounds of nuggets were prepared from frozen pollock fillets processed aboard the *Arctic Trawler* in western Alaska waters. Here is the recipe for those who missed the open house:

Alaska Pollock Nuggets

- 1 pound fish fillets or minced fish, precooked
- ½ cup mashed potatoes
- 1 tablespoon grated onion
- 1 tablespoon butter or other fat, melted
- ¼ teaspoon each of salt and celery salt
- 1 dash pepper
- 1 teaspoon Worcestershire sauce
- 1 egg, well beaten
- ¼ pound sharp cheese
- 1 cup dry bread crumbs
- ¼ teaspoon parsley flakes

A variety of white-fleshed fish can be used. If the fillets or minced fish are uncooked, wrap the fish in aluminum foil and bake at 375°F for 15 minutes, drain, and flake. Leftover fish can also be used. Combine all ingredients except cheese and crumbs and mix thoroughly. Shape into balls the size of walnuts. Cut cheese into ¾-inch cubes. Insert a cheese cube into the center of each fishball and reshape. Roll in bread crumbs. Fry in deep fat at 375°F for 3 to 4 minutes or

until golden brown. Garnish and serve hot, plain, or with a sauce. Serves 6.

Jerry Babbitt

Improving the Keeping Quality of Frozen Widow Rockfish Fillets

Initial tests on the keeping quality of frozen widow rockfish fillets by the Utilization Research Division, Northwest and Alaska Fisheries Center (Mar. Fish. Rev. 43(8):24), indicated that after 4 months at 0°F, the fillets were of unacceptable quality due primarily to moderate to severe rancidity of the exposed dark flesh. A second study of frozen widow rockfish (usually marketed fresh as Pacific snapper) is now in progress, in which the fillets were treated prior to freezing by dipping in a solution of 4 percent sodium tripolyphosphate and 2 percent hexametaphosphate with 2 percent sodium erythorbate and 2 percent sodium chloride. Treated and untreated (control) fillets were then packaged, frozen, and stored at 0° and -30°F.

After 6 months of storage, the treated rockfish fillets showed only moderate changes in quality compared with the severe quality deterioration shown by the untreated rockfish fillets. Sensory tests showed that rancidity of treated fillets was slight to not detectable, whereas untreated fillets were definitely rancid in surface dark flesh and therefore of unacceptable quality. Although some toughening of the flesh was noted during storage, the treated samples were rated at acceptable texture and juiciness after 6 months, compared with the controls in which moderate to excessive toughening and apparent after only 2 months at either 0° or -30°F. The tests will continue and should be confirmed by additional series studies of frozen widow rockfish. The unprecedented increase in widow rockfish landings in Oregon during the last 2 years has made it difficult to expand the fresh market rapidly. Our research will continue on methods of improving the keeping quality of both the fresh chilled and packaged frozen rockfish fillets.

Harold Barnett

The Sicilian Fishing Industry

Introduction

The fishing industry, an important segment of the Sicilian economy, is now making special efforts to modernize and expand to take advantage of high potential profits resulting from increasing demand and high fish prices. But the industry faces serious problems, including increasing obsolescence of the fleet, inefficient marketing facilities, fish depletion in local waters, and disputes with Libya, Tunisia, and Malta over fishing rights in areas of the Mediterranean those nations claim as territorial waters.

The Sicilian tuna fish canning and preserving industry, which in the middle 1960's was doing fairly well, has gradually declined. However, in recent years, a number of shrimp processing plants have been established.

Improved technology and marketing techniques are being introduced, and the Sicilian Regional Government, which is highly sensitive to the industry's problems, recently enacted legislation designed to stimulate and aid the fishing industry.

Economic Role

Sicily's 300 billion lire (US\$385 million) fishing industry plays a significant role in the island's economy. The net income derived from commercial fishing alone (which in 1977 represented a quarter of Italy's total net income from this sector) nearly doubled in 5 years (68 billion lire in 1977 vs. 36 billion lire in 1973).

Fishing and related fields provide one of the main sources of livelihood for the island's coastal inhabitants, employing some 80,000 persons. Mazara del Vallo is the leading Sicilian fishing center. Other important centers are Palermo,

Trapani, Sciacca, Porto Empedocle, Messina, and Siracusa.

Fishing Fleet

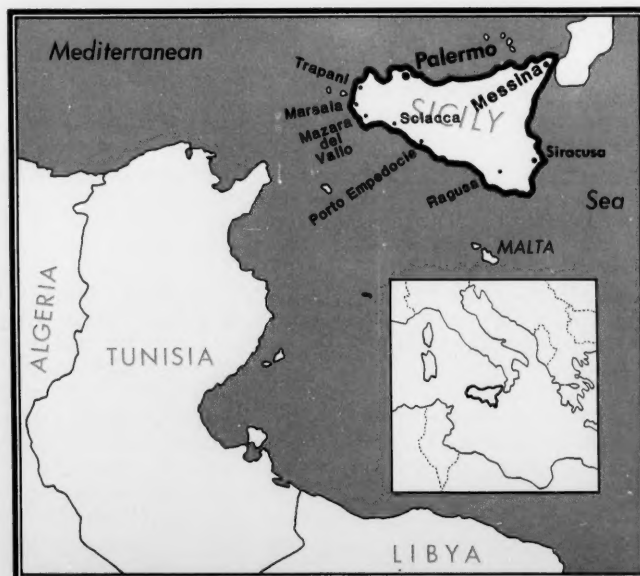
The Sicilian fishing fleet is Italy's largest, representing one-fourth of the Italian total. It consists of 1,005 trawlers with a total gross tonnage of 53,675, and 4,864 small motor and sail boats. But much of the fleet is obsolete and poorly equipped. Even many of the larger trawlers are unable to undertake long voyages or engage in deepwater fishing. Moreover, there are no factory ships to process and refrigerate the catch. In recent years, because of these handicaps and the

scarcity of fish in their own coastal waters, the Sicilians have fished mainly in the channel between Sicily and Libya and Tunisia. But lately this has led to serious diplomatic strains (see section on Problems).

Coastal tuna fishing, formerly a virtual Sicilian monopoly, has declined drastically over about the last 20 years. Most of the tuna catch nowadays is taken at sea by mainland (principally Neapolitan) fishermen using "flying nets" and fast, radar- and sonar-equipped boats.

Consumption and Marketing

Italian Government statistics (ISTAT) place Sicily's annual catch, including shellfish and mollusks, at between 45,000 and 50,000 metric tons (t), but Palermo Regional Government officials say the true figure is much higher—at least 70,000-80,000 t. Sicily also imports between 5,000 and 7,000 t of fish annually, mainly from South Korea, Spain, the U.S.S.R., and the United States. Sicilians harvest a wide range of fish, including swordfish, shrimp, anchovies, sardines, and mackerel.



As the Sicilian fleet has not been able to meet the rising demand for fish, local dealers are having to look more and more to foreign sources, and to this end have lately begun acquiring more freezing facilities and refrigerator trucks. The Palermo fish market, Sicily's largest, is also expanding and modernizing its wholesale distribution facilities and installing new refrigeration and conservation equipment.

Fish Processing

Over the last 15 years changes in supply and demand, greater selectivity by the public, and improved technology brought major transformations in the Sicilian fish processing industry. With the decline of the tuna catch in coastal waters, the number of tuna canneries in Sicily dropped from 12 in the 1960's to only 2 at present. Meanwhile, efforts have been directed toward the development of other processing activities, most importantly shrimp freezing, mainly in Mazara del Vallo where a dozen plants are now operating. The largest, Italgel, was built in 1977 by the Sicilian Industrial Promotion Agency (ESPI).

Problems

Although the Sicilian fishing industry continues to be profitable, owing to high retail prices and strong demand for fish, a number of serious and persistent problems cloud its future. The depletion of Sicily's coastal fish resources from overfishing and increasing industrial pollution, while the subject of increasing public attention and concern, continues. And the ever-rising cost of diesel fuel is a growing economic burden to boat operators, who report fuel now represents up to 50 percent of operating costs.

Fishermen are also worried and angry about the growth of "sea resources nationalism" in the Mediterranean, which limits their access to choice fishing areas. For years, under a 1963 agreement between Italy and Tunisia, Sicilian boats were permitted to fish undisturbed in specified areas near the Tunisian coast. But the agreement expired 19 June 1980, and the Tunisians had thus far declined to renew or extend it. Nonetheless, many Sicilian boats continued to fish in the relatively rich Tunisian and Libyan wa-

ters because owners considered the potential rewards were worth the risk. But this has caused considerable friction. Over the past 5 years, Tunisian, Libyan, and Algerian gunboats have seized 104 Sicilian trawlers and detained their crews until payment of stiff fines. In one incident in July 1980, the Tunisians actually fired on the Sicilians, killing one Mazara fisherman. More recently, the Libyans detained 12 Sicilian crewmen for 7 months and released them only after the Italian Minister of Foreign Affairs intervened on their behalf. In the fall of 1980 Mazara fishermen kept their fleet in port for a month to protest the detention of fishermen and call the attention of Italian authorities to their plight.

In 1980, Malta created a new problem for Siracusa and Ragusa fishermen when it abruptly extended its offshore jurisdiction to 25 miles. The deterioration in relations with nearby Mediterranean states over fishing issues and the slight chance of any resolution of these problems in the near term accounts for a certain pessimism voiced by fishing spokesmen in Mazara del Vallo in recent months. The risks and costs of fishing as usual in North Africa waters are on the rise.

Prospects

The Sicilian Government, in cooperation with the fishing industry, has devised a comprehensive program to reorganize and further expand the sector. It calls for promotional legislation, development of aquaculture, and efforts to find new fishing grounds and to resolve the disputes with Tunisia and Libya in a way that would permit the Sicilians to regain access to the rich fishing grounds off their coasts.

As a first step, in November 1980 the Sicilian Regional Assembly enacted legislation providing for the establishment of aquaculture projects in coastal waters, subsidies for modernization of the fishing fleet, and the application of advanced technology in the processing industry. The law, which was officially promulgated on 12 January 1980, also encourages the formation of fishermen's cooperatives. An initial allocation of 75 billion lire (about US\$9.5 million) was appropriated for the program for the

period 1980-82. Financial incentives (up to 80 percent for private operators) are being offered for the construction of trawlers of between 30 and 200 tons, provided owners demolish old vessels of a total capacity of at least 80 percent of the new vessel's tonnage. Other incentives are available for alterations and repairs on existing vessels.

The new law should be an overall plus for the Sicilian fishing industry, but it is questionable whether it can do much to promote early settlement of the problems with Tunisia and Libya. In fact, some local observers (including the State Commissioner for Sicily, Giorgio Brancata) believe the law could even complicate things for the National Government in Rome and the EEC (which is now the competent authority to conduct such negotiations for all Member States), in that expansion and modernization of the fleet would probably result in Sicilian fishing outside their own waters—and getting into trouble—to an even greater extent than has been the case up to now. Moreover, the Tunisians have indicated that they are interested only in a comprehensive agreement under which, in exchange for granting fishing rights, they would be allowed to sell more of their agricultural products, such as olive oil and almonds, in Western Europe. They are also unhappy about the oil drilling being conducted by ENI, the Italian Hydrocarbon Agency, on behalf of the Libyan government in waters contested by Libya and Tunisia, and this could further complicate prospects for a new agreement.

The outlook with Libya does not appear much better. The Libyan government has long pressed for joint venture arrangements with Italian firms under which the Libyans would share in the catch and the profits, but the Sicilians have been hesitant to enter any agreement that would leave them as minority partners. Such arrangements, however, could well turn out to be the only means by which Italian fishermen can regain access to areas now off limits to them. In an interview in Palermo on 22 March 1980, Italian Foreign Minister Ruffini urged Sicilians to consider establishing joint ventures with Libya. One such agreement was reached in January 1980

with Egypt which allows seven Mazara boats to fish in the Red and Mediterranean seas and sell the catch in Egypt. (The Italian government is to pay half of the operating expenses, the fishing firms the other half.)

Concern for the welfare of the fishing industry was expressed at the national level at a conference held in Rome on 21 March 1981. The conference, sponsored by CNEL (National Committee for the Economy and Labor) was attended by representatives from ministries, public bodies, and the fishing industry. Speakers emphasized the need for scientific research, protection of fishing resources, and cooperation with other Mediterranean countries. According to the head of the Sicilian Regional Fishing Bureau, who attended the conference, emphasis was placed on improving the Italian industry in order to reduce fish imports, now valued at 600 billion lire annually. He said the measures proposed at the conference did not seem to go much beyond those already provided for in the

new Sicilian Regional Government's fishing law.

Sicily's age-old fishing industry confronts both opportunity and challenge as the new decade begins. With quality fish currently selling for as much as 20,000 lire per kilo (about US\$11 a pound) in Palermo, and supply unequal to demand even at such prices, ship-owners and fish processors are still making money, notwithstanding their high operating costs. There appears to be little likelihood, at least in the short term, that the fish catch in Sicilian waters can be increased significantly. Upgrading the fleet and adopting more modern fishing techniques would probably lead to an increase in the overall catch for a time, but the basic problems—the decline of the fish population from over-fishing and pollution, and the frictions with other nations of the Mediterranean littoral over fishing grounds—are not likely to go away.

Some knowledgeable industry observers believe the best option for Sicily

may lie in developing additional fish resources via aquaculture. Several aquaculture schemes are under consideration, including an ESPI plan for a pilot sea farm on the west coast, north of Marsala. In the near term, Sicilian fishermen will probably continue to fish, and become involved in incidents in, North African waters, and there will likely be increased interest in fishing in the Atlantic (one Sicilian firm—Cefalu—is already sending boats to West African and U.S. waters) unless and until the cost of diesel fuel increases as to make that an unprofitable option. Meanwhile, government subsidies will probably loom ever more important to the fishing sector, as they have for so many other Italian industries, during a difficult period of transformation.

Norway, Russia Agree on Fisheries Quotas

The Soviet Union and Norway have reached agreement that the cod quota in the Barents Sea this year will be 340,000 t (same as last year), according to the Norwegian Information Service. Of this, 40,000 t are to be coastal cod. The Soviet Union had initially demanded a reduction of the cod catch to 140,000 t.

The cod catch is to be divided 50-50, but in addition, 45,000 t are to be transferred from the Soviet to the Norwegian quota, as well as 25,000 t of haddock. The total haddock catch was put at 110,000 t, plus 10,000 t to a third country.

The aggregate capelin catch will be 1.7 million t, 900,000 t of summer capelin and 800,000 t of winter capelin. Norway already had 60 percent of this quota, and then transferred 70,000 t of winter capelin and 40,000 t of summer capelin. This means that Norway had in effect two-thirds of the quota by late last year.

The Soviet fishermen will be permitted to fish 470,000 t of blue whiting, 185,000 t in the Norwegian zone and the rest in the Jan Mayen zone. There will also be an opportunity to apply for a bigger quota, should there be need for it. The Soviet Union may also fish 54,000 t of redfish and 2,400 t of Greenland halibut in the Norwegian zone.

Russia-Japan Conclude Fishery Pacts for 1982

The Soviet and Japanese government representatives in Moscow on 16 December 1981 signed a protocol to bilateral interim agreements for 1982 which regulate mutual fishing operations and catch quotas within their respective 200-mile fishing zones. Under the agreements, both Japan and the Soviet Union will retain the same total quotas as in the previous 3 years, 750,000 metric tons (t) for Japan and 650,000 t for the Soviet Union. Catch quotas for the species in which each country has primary interest also remained unchanged, 290,000 t of Alaska pollock for Japan and 500,000 t of combined sardine and mackerel for the Soviet Union.

The agreements introduced expansion of fishing zones in two areas in the northern Sea of Japan, one west of Sakhalin for Japan and the other west of Hokkaido and northern Honshu for the Soviet Union.

A breakdown of the 1982 catch quotas is shown in Table 1.

Table 1.—Russian and Japanese catch quotas for 1980-82.

Species	Quotas (t)		
	1980	1981	1982
Soviet quotas in Japanese zone			
Sardine and mackerel	500,000	500,000	500,000
Alaska pollock	30,000	20,000	10,000
Itohiki-Jara (hakeling)	80,000	90,000	90,000
Saury	10,000	10,000	10,000
Sand lance	10,000	10,000	0
Others	20,000	20,000	40,000
Total	650,000	650,000	650,000
Japanese quotas in Soviet zone			
Alaska pollock	290,000	290,000	290,000
Flounder	24,800	24,600	24,600
Pacific cod	34,000	32,600	33,200
Wachna cod	15,500	15,500	15,500
Saury	68,600	68,600	68,600
Atka mackerel	11,300	11,300	11,700
Sand lance	43,800	43,000	43,000
Shark	1,200	1,200	1,200
Tuna	6,400	6,400	6,400
Rockfish	16,900	17,900	17,900
Squid	142,900	146,200	146,400
Octopus	3,600	3,600	4,200
Tanner crab	2,500	2,800	2,800
Red tanner crab	2,600	2,600	2,600
Korean hair crab	800	800	800
Spiny crab	800	800	800
Shrimp	500	500	500
Snail	3,000	3,500	3,500
Others	80,800	78,100	76,300
Total	750,000	750,000	750,000

Japanese 1980 Marine Fish Catch Sets Record

Japan's marine fish catch in 1980 set a new record, aided by a record-setting performance by the offshore fisheries and improved catches by the distant-water and coastal fisheries (Table 1), according to the statistics released by the Ministry of Agriculture, Forestry, and Fisheries. The total catch for the year was 9,908,554 metric tons (t), a 5 percent gain over 1979 and a new record over the previous high of 9,793,029 t in 1973.

By type of fisheries, the distant-water fisheries caught 2,121,000 t (+4 percent), reversing a 6-year decline since 1974. The offshore fisheries caught 5,751,000 t (+5 percent), a new high, and the coastal fisheries, with catches totaling 2,037,000 t (+4 percent), returned to a 2 million t level for the first time in 3 years since 1977.

By species, significant gains were recorded in the catches of sand lance (+82 percent), herring (+64 percent), common squid (+56 percent), searobin (+37 percent), and frigate mackerel (+36 percent), whereas sharp declines occurred in king crab (-79 percent), jack mackerel (-35 percent), and saury (-33 percent) (Table 2).

The most important species landed in terms of quantity was sardine, as in 1978 and 1979, with a catch of 2,441,961 t (+19 percent), followed by Alaska pollock with 1,552,421 t (no change). The third in importance was mackerel, which, at 1,301,122 t, showed a decrease of 8 percent over 1979. Sardine, Alaska pollock, and mackerel together accounted

Table 1.—Japan's marine fisheries catch by type of fisheries, 1972-80.

Type of fisheries	Catch (x 1,000 t)								
	1972	1973	1974	1975	1976	1977	1978	1979	1980
Distant-water	3,905	3,988	3,698	3,168	2,949	2,657	2,134	2,035	2,121
Offshore	3,594	3,984	4,178	4,469	4,656	4,924	5,559	5,488	5,751
Coastal	1,902	1,820	1,874	1,935	2,000	2,107	1,990	1,953	2,037
Total	9,400	9,793	9,749	9,573	9,605	9,688	9,683	9,477	9,909

Table 2.—Japan's marine fisheries catch by selected species, 1979 and 1980.

Species	Catch (t)		Species	Catch (t)	
	1980	1979		1980	1979
Tuna			Rockfish	31,310	40,447
Bluefin	49,494	44,241	Rockcod	11,870	9,927
Albacore	69,677	66,822	Sandfish	12,333	10,179
Bigeye	123,168	130,466	Croaker	32,025	39,444
Yellowfin, large	119,001	99,659	Butterfish	912	1,364
Yellowfin, small	17,156	21,729	Hairtail	37,803	30,518
Total	378,496	362,917	Searobin	3,395	2,473
Skipjack			Sea bream	28,151	28,825
Skipjack	354,156	329,948	Dolphin fish	10,280	9,470
Frigate mackerel	22,582	16,570	Flying fish	7,690	8,761
Total	376,738	346,518	Mullet	11,727	11,651
Billfish	44,122	43,357	Seabass	10,002	9,544
Shark	42,286	42,480	Sand lance	201,209	110,484
Ray	11,884	9,496			
Salmon	122,515	131,021	Shrimp	50,505	52,661
Herring	11,154	6,819	Crab		
Sardine	2,441,961	2,056,358	King	57	270
Spanish mackerel	7,045	6,140	Tanner	21,314	23,476
Jack mackerel	144,979	183,883	Blue	2,807	3,905
Mackerel	1,301,122	1,414,183	Other	53,911	52,618
Saury	187,155	277,960	Total	78,089	80,269
Yellowtail	42,009	44,970	Squid		
Flatfish	288,881	288,896	Common squid	331,933	212,841
Cod			Cuttlefish	10,409	14,137
Cod	96,742	91,829	Other squid	343,740	301,853
Alaska pollock	1,552,421	1,551,116	Total	686,082	528,831
Total	1,649,163	1,642,945	Octopus	46,106	51,986
Atka mackerel	117,351	118,888	Sea urchin	24,158	26,500
			Sea cucumber	8,969	9,381
			Shellfish	337,885	357,490

for 53 percent of the total marine catch for 1980, the same as 1979.

Total 1980 landings of fisheries and fish culture products for 1980 hit 11,092,000 t, up 5 percent from the 1979 figure, according to data released by the Ministry of Agriculture, Forestry, and

Fisheries. Also showing an increase was marine culture at 992,000 t, up from 883,000 t in 1979. Decreasing slightly were inland fisheries, at 128,000 t compared with 136,000 t for 1979, and inland fish culture (94,000 t compared with 95,000 t in 1979). (Source: FFIR 81-21.)

Norway Tries Trout Caviar

A new type of caviar made from trout roe will soon be competing with the traditional Russian brand, reports the Norwegian Information Service. Tasters who have sampled the product claim that it is on a par with the finest caviar on the international market.

The first production plant was scheduled to start operation on the island of Frøya, in mid-Norway, in March. Initial annual production is set at 50 t of caviar,

at a first-hand value of \$3.3 million. The industrial production method for trout caviar was discovered by an Icelandic concern in cooperation with the Fisheries Research Institute of Iceland. The main problem has been to separate the actual roe from the membrane enclosing it, and the Icelanders have found a way to do this. This method, now patented, is based on accelerating ovulation with the aid of salt and heat, without causing the

eggs to ripen more.

Norway has secured first rights to the processing plants which the Icelandic firm delivers. The intention is to establish 6-7 such plants along the Norwegian coast beside already established fisheries industries. The plans involve production for two plants this year. Price of a 50 g jar of the new product, with first-hand value of \$33/kg from the factory will be about \$3 at retail.

Brazilian Fisheries and Licensing Regulations

Brazil is one of Latin America's most important fishing countries. The 1980 catch was about 927,000 metric tons (t), excluding subsistence fishing.

Brazil claimed a 200-mile territorial sea on 27 March 1970 when law No. 1098 was approved by the Brazilian Government. Regulations for foreign fishermen were promulgated on 1 April 1971 with Decree Law No. 68459. Brazilian officials may reportedly modify their 200-mile territorial sea claim to an Exclusive Economic Zone (EEZ) claim in order to bring Brazil more in line with the emerging Law of the Sea consensus. Such a modification, however, would not affect the Brazilian regulations for foreign fishermen.

Brazilian officials have discouraged foreign distant-water fishing since 1978. Foreign-flag shrimp trawlers used to operate extensively off the country's northern coast, but in 1978 the Brazilian Government began to seize U.S. and other foreign vessels which continued to fish there. There are provisions in Brazilian law, however, which do permit foreign vessels to operate off Brazil, and fishermen from several countries have taken advantage of these provisions.

Brazilian regulations permit four categories of licenses for foreign fishermen: Special licenses, charter contracts, joint ventures, and bilateral agreements. While permitted by law, there are no known examples of Brazilian officials actually approving the special licenses.

Charter contracts are licenses for foreign vessels chartered by Brazilian fishing companies. These are routinely approved by Brazilian officials. Such charters authorize exploratory fishing for species not currently fished and commercial fishing for species not fully utilized by Brazilian fishermen. Joint venture licenses can also be obtained by Brazilian companies which have formed joint ventures with foreign fishermen¹.

Licenses can be obtained under bilat-

eral agreements with foreign governments. Brazil has negotiated several such agreements with neighboring countries, but no known fishing operations have yet resulted from these agreements. Brazil signed a fishery agreement, for example, with Trinidad in 1978. Even though Trinidad badly needs access to fishing grounds for its fleet, Brazil has not yet issued such licenses. Brazilian officials have insisted on a joint venture framework even when agreeing to a bilateral licensing system.

Applications for licenses must be submitted to the Superintendency for Fisheries Development (SUDEPE) in the Ministry of Agriculture by a Brazilian company which assumes legal and financial responsibility for the operations of the foreign fishermen. Foreign fishermen obtaining licenses must pay a \$500 registration fee and a \$20 per net-registered-ton licensing fee. The licenses are valid for 1 year and can be renewed annually. Foreign fishermen are only authorized to fish outside a 100-mile coastal strip; the latter is reserved ex-

clusively for Brazilian fishermen. All fish caught in Brazilian-claimed waters must be landed in Brazilian ports.

Violations of Brazilian regulations for foreign fishermen are punishable under the country's criminal code. Fines vary according to many different factors and circumstances as established in chapters IV and VII of Decree Law No. 211, dated 28 February 1967 and modified by Law No. 6276, dated 1 December 1975. Brazilian officials have been fining U.S. shrimp fishermen seized off Brazil about \$2,000 per vessel and have also been confiscating their gear and catch. Brazilian officials have, however, recently decided to deal more strictly with foreign fishermen and have begun to also confiscate vessel equipment other than actual fishing gear. (Source: IFR-81/156.)

Another report prepared by the U.S. Embassy in Brasilia on the country's fishing industry, including details about the licensing of foreign fishermen, can be purchased for \$6.50 by ordering report number DIB-81-03-092 from NTIS, Springfield, VA 22161.

Japan's Chum Salmon Catch Hits New High

Japan's fall chum salmon catch off Hokkaido, which has sharply increased in recent years, totaled 20,921,592 fish by the end of November 1981, an all-time record high according to preliminary data released by the Japan Fisheries Agency's Hokkaido Salmon Hatchery. Catch figures (by area) and comparisons with 1980 are shown in Table 1.

The catch also exceeded predictions

by the Hokkaido Salmon Hatchery. It had been earlier forecast that the chum catch would be high, but probably the second largest in history. These data are also included in Table 1. The chum salmon catch in previous years (cumulative total to 30 November) was 18,361,000 in 1979, 12,474,000 in 1978, and 9,557,000 in 1977. (Source: FFIR 82-22.)

Table 1.—Japan's fall chum salmon catch off Hokkaido (cumulative to 30 November).

Area	Catch (no. of fish)		1981 forecast (no. of fish)			
	1980	1981	Total	3 years old	4 years old	5 years old
Pacific Ocean						
Nemuro area	4,193,110	5,561,523	5,851,500	1,669,400	3,669,700	472,400
East of Cape Erimo	4,437,045	5,674,232	3,060,000	420,700	1,911,400	727,900
West of Cape Erimo	1,968,834	3,207,928	2,750,000	839,300	1,768,600	142,100
Okhotsk Sea	3,409,519	5,385,320	4,128,200	1,931,700	2,016,600	180,500
Japan Sea	566,209	1,092,589	880,300	336,200	509,100	34,900
Total	14,574,717	20,921,592	16,660,000	5,197,400	9,904,800	1,557,800

¹Additional details on charters and joint ventures are given in Foreign Participation in Brazilian Fishing Industry. Mar. Fish. Rev. 44(1):30.

Tasman Sea Squid Studies Find Gill Nets Effective

Catches by the Taiwanese research vessel *Hai Kung* in the Tasman Sea have demonstrated that surface gillnetting is an effective technique for catching oceanic squid in this region, according to a report in *Australian Fisheries*. The *Hai Kung* caught some 1,200 kg of the oceanic squid species *Ommastrephes bartrami* in seven sets during a 17-day exploratory cruise from Auckland to Melbourne a year ago (Table 1).

During this cruise, the 56.6 m, 712 t vessel routinely used surface plankton nets and freefall drop nets to try to obtain larval squid (only a small number were caught) and recorded oceanographic data at four other points (see map).

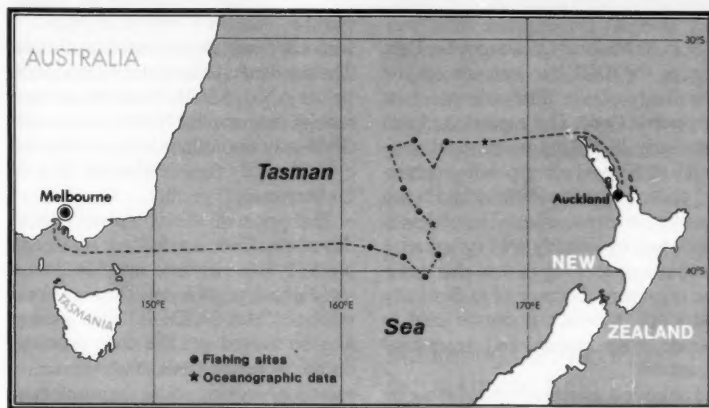
The gill net used consisted of panels about 25 m long with a stretched mesh of 110 cm. Each panel had one or two buoys (14.5 kg buoyancy, 30 cm diameter) attached to the floatline, making the net easy to see in the water. A radio transmitter was coupled to one end of the net, and two flashing beacons and a large buoy were attached to the end from which hauling would commence.

The net usually had 70 panels, although once (at station 11), a further 60 panels were added. The net was set at dusk. Hauling, the most critical part of the fishing operation, began shortly after the first light. Unfavorable conditions (swell greater than 3-4 m, winds force 4 and above) caused considerable problems; at times the net had to be cut to prevent it drifting under the ship and

Table 1.—Fishing station and catch data.

Date	Set			Haul			Catch (kg)	
	Duration ¹	Latitude	Longitude	Duration ¹	Latitude	Longitude	Squid	Other
12 Jan. 1981	13	34°59'	165°59'	85	34°55'	165°58'	2	42
15	15	36°59'	163°35'	123	36°59'	163°34'	114	60
16	13	36°56'	164°15'	140	37°57'	164°10'	156	21
18	32	39°29'	165°18'	105	39°21'	165°10'	193	26
19	10	40°32'	164°49'	82	40°32'	164°49'	240	40
20	13	39°40'	163°28'	123	39°39'	163°28'	141	34
21	22	39°02'	161°59'	260	39°06'	161°59'	349	48

¹Minutes.



fouling the propeller.

Although three automatic jigging machines were installed on the port side and one of these was used on several occasions after setting the net, only one squid was caught this way. However, squid were observed swimming at the surface on a number of nights and several were caught by the crew on a variety of hand jigs.

Over 80 percent of the catch was made up of the oceanic squid *Ommastrephes bartrami*. This species occurs throughout subtropical waters of the Southern Hemisphere and northwestern Pacific, and has been the second most important species to the Japanese local fishery in recent years (where annual landings totalled 180,000 t in 1980).

The balance of the catch consisted of albacore, *Thunnus alalunga*; skipjack tuna, *Katsuwonus pelamis*; shortfin mako, *Isurus oxyrinchus*; Ray's bream, *Brama brama*; and blue shark, *Prionace*

glauca. A single specimen of another oceanic squid, *Todarodes filippovae*, distributed around the subtropical convergence zone in the Southern Ocean, was caught on a hand jig at Station 8.

During the cruise, immature females of 40 cm (mantle length) weighing over 2 kg were caught frequently. It is interesting that no oceanic squid less than 27 cm mantle length were caught by the net although specimens of 19 cm mantle length were caught on hand jigs. Scientists believed that the population consisted of several cohorts, with the net selecting only the larger individuals.

The catches by *Hai Kung* demonstrated that surface drift-netting using monofilament nets can be an effective method of catching oceanic squid. However, the scientists believe that more research to define the squid resource is needed before significant involvement by the Australian fishing industry can be considered.

Note: Unless otherwise credited, material in this section is from either the Foreign Fishery Information Releases (FFIR) compiled by Suneo C. Sonu, Foreign Reporting Branch, Fishery Development Division, Southwest Region, National Marine Fisheries Service, NOAA, Terminal Island, CA 90731, or the International Fishery Releases (IFR), Language Services Biweekly (LSB) reports, or Language Services News Briefs (LSNB) produced by the Office of International Fisheries Affairs, National Marine Fisheries Service, NOAA, Washington, DC 20235.

NODC Taxonomic Code and Marine Science Acronyms

NOAA's National Oceanographic Data Center (NODC) has announced the availability of the third edition of its **Taxonomic Code**. This expanded edition has nearly 28,000 entries giving the scientific names and corresponding numerical codes of worldwide flora and fauna from viruses to mammals. The code was developed to simplify and systematize computer processing of data about marine organisms. Because of its flexibility and scope, however, it can be used to encode both aquatic and terrestrial organisms.

The code has been adopted for use by several major environmental assessment and monitoring projects, including NOAA's Marine Ecosystems Analysis (MESA) project and the Outer Continental Shelf Environmental Assessment Program (OCSEAP) conducted by NOAA for the Department of Interior's Bureau of Land Management. At NODC the code is used in all data bases containing data about organisms. It facilitates the merging, intercomparison, and mutual exchange of data collected by different investigators and the production of uniform computer-generated data plots, summaries, and other products. NODC recommends the code for use by all marine environmental researchers and requires its use in all projects from which biological data are submitted to NODC.

The NODC Taxonomic Code is available either as hard copy printout or on magnetic tape. The hard copy printout (on $8\frac{1}{2} \times 11$ inch pages) includes code listings sorted both numerically (code order) and alphabetically (scientific name order). On magnetic tape the two

sort orders may be requested separately. The standard tape format is 9-track, 1600 bpi, in ANSI/ASCII. Users who do not require the complete NODC Taxonomic Code may also obtain subsets of it, for example, only those codes for birds or for mammals.

The price of the complete NODC Taxonomic Code is as follows: Hard copy printout, \$16; magnetic tape, \$70 (please make check payable to: "Dept. of Commerce/NOAA/NODC"). This charge may be waived and the code provided on an exchange basis, however, to researchers working under the auspices of projects from which NODC receives data or information. Orders and inquiries should be directed to: National Oceanographic Data Center, NOAA/EDIX OA/D761, Washington, DC 20235.

NOAA has also announced the availability of the "**Annotated Acronyms and Abbreviations of Marine Science Related Activities**" (Third Edition). The revised, expanded edition of a reference work first published in 1969, the "Annotated Acronyms" is designed to help research scientists, program managers, students, technical writers, and others cope with a literature strewn with acronyms of marine science organizations, programs, projects, expeditions, instruments, and institutions.

Originally covering only acronyms and abbreviations of international marine science activities, this publication now includes five major sections: I, International organizations; II, International programs, projects, and expeditions; III, United States national organizations; IV, Foreign organizations; and V, Terms. The U.S. section covers the Federal

Government, State agencies and organizations, regional organizations, and private organizations; the foreign section is a survey by country.

The organization and format of this publication make it more than a list of acronym titles. Acronyms and abbreviations are described in context by entries that are arranged to show pertinent relations. Two alphabetical indexes—one listing acronyms and abbreviations and one listing full titles—provide keys to the text entries.

There is a \$3 handling charge for the 349-page item, and it is also available from the NODC.

The Early Lives of Marine Fishes

Publication of "**Marine Fish Larvae**," subtitled "Morphology, Ecology, and Relation to Fisheries," has been announced by the University of Washington Sea Grant Program, Seattle. The volume was edited by Reuben Lasker, Chief, Coastal Fisheries Resources Division, NMFS Southwest Fisheries Center, and coauthored by SWFC research biologists Paul E. Smith, H. Geoffrey Moser, John R. Hunter, and Lasker.

The book is based on a series of lectures given by the authors at the U.W. College of Fisheries in 1979. Smith discusses "Fisheries on Coastal Pelagic Schooling Fish," "Sampling to Determine Anchovy Larval Mortality in the Sea," and "Larval Anchovy Patchiness."

Hunter examines "Feeding Ecology and Predation of Marine Fish Larvae"; Lasker has authored "The Role of a Stable Ocean in Larval Fish Survival and Subsequent Recruitment"; and Moser discusses "Morphological and Functional Aspects of Marine Fish Larvae." Well written and edited, this book provides an excellent and authoritative account of the larval life history of marine fishes. It is also a companion volume to "Early Life History of Marine Fish: The Egg Stage" by Gotthilf Hempel. A third related report, "Early Life History of Eastern North Pacific Fishes in Relation to Fisheries Investigations" by A. W.

Kendall, was published last year as Technical Report WSG 81-3 by the University of Washington Sea Grant Program.

This paperbound volume, 131 pages, illustrated, is available from the distributor, the University of Washington Press, Seattle, WA 98105 for \$8.50.

Marine Ecosystems and Their Analysis

Publication of "Analysis of Marine Ecosystems" has been announced by Academic Press Inc. (London) Ltd. The volume, edited by Alan R. Longhurst of the Bedford Institute of Oceanography, Dartmouth, Nova Scotia, is presented in three sections.

Part 1, Current Concepts of Marine Ecosystems, contains reviews of the trophic and energetic relationships within a range of exemplary marine ecosystems. Part 2, Functions Within Ecosystems, comprises reviews of some important processes which are common to many marine ecosystems which have been long studied. And Part 3, Simulation and Experimental Studies of Marine Ecosystems, presents six chapters on studies of marine ecosystems by the use of numerical simulation, by the use of microcosms, and by the manipulation of natural ecosystems.

Part 1, Current Concepts, contains review chapters on "Low latitude gyral regions" by Maurice Blackburn; "Coastal upwelling ecosystems" by Richard T. Barber and Robert L. Smith; "Ecosystems of equatorial upwellings" by Mikhail E. Vinogradov; "High latitude ecosystems" by Takahisa Nemoto and Glen Harrison; "Coral reef ecosystems" by John B. Lewis; "Shelf-sea ecosystems" by John J. Walsh; "Fronts and eddies in the sea: Mechanisms, interactions, and biological effects" by Robert W. Owen; and "The deep-sea ecosystem" by Gilbert T. Rowe.

Part 2, Functions Within Ecosystems, presents chapter reviews on "The trophic role of dissolved organic material" by Grover C. Stephens; "Microheterotrophic organisms in marine ecosystems" by Yu. I. Sorokin; "Autotrophic production of particulate matter" by Richard W. Eppley; "Nutritional strate-

gies for feeding on small suspended particles" by Robert J. Conover; "The role of large organisms" by G. Carleton Ray; "Significance of spatial variability" by Alan R. Longhurst; "Temporal variability in production systems" by David H. Cushing; "Comparative function and stability of macrophyte-based ecosystems" by C. Peter McRoy and Denby S. Lloyd; "Lipids and hydrocarbons in the marine food web" by John R. Sargent and Kevin J. Whittle; and "Elemental accumulation in organisms and food chains" by Michael N. Moore.

Chapters in Part 3 include "Theory and observation: Benthic predator-prey relationships" by Brian L. Bayne; "Field experiments on benthic ecosystems" by Bernt Zeitzschel; "Microcosms and experimental planktonic food chains" by Carl M. Boyd; "Principles of ecosystem modelling" by William L. Silvert; "Simulation models of individual production processes" by Philip J. Radford, Ian R. Joint, and Alex R. Hily; and "Holistic simulation models of shelf-seas ecosystems" by Taivo Laevastu and Felix Favorite.

In sum, the volume provides a good synoptic view of the current status of marine ecology and especially of those parts concerned with the analysis of ecosystem function. Well written and well edited, readers will find the book to be a good and useful review of the present level of understanding, of the uncertainties, and the current progress toward a better understanding of marine ecosystems.

Indexed, the 741-page hardbound volume is available from Academic Press Inc., 111 Fifth Avenue, New York, NY 10003 for \$125 (£52).

Processing Krill the German Way

"Die Verarbeitung Von Krill Zu Lebensmitteln," by W. Schreiber, W. Flechtenmacher, and O. Christians, has been published by the Bundesforschungsanstalt für Fischerei, Institut für Biochemie und Technologie, in Hamburg. Its English title would be: "Processing of Krill Into Food."

It is a compilation and evaluation of

the experiences and results obtained through 1979 while processing krill into food. Force meat from steamed krill may be the key intermediate for the production of various foodstuffs, say the authors, and special emphasis has been put into developing methods for preparing boiled or cured sausages from this force meat and other ingredients like minced fish and lard. Preference given to force meat and its processing into sausages was based on economic considerations (the yield of force meat is reportedly five times the yield of tail meat from peeling raw krill) and gauging German food habits.

Unfortunately the entire text is in German; a table of contents and a very brief summary are in English. The 215-page, illustrated, paperbound book is available from the Institute of Biochemistry and Technology, Federal Research Center for Fisheries, Palmaille 9, 2 Hamburg 50, West Germany for \$10 plus \$2 airmail postage.

Marketing Canned Fish in the United Kingdom

The United Kingdom imported over \$170 million worth of canned fish in 1980. Except for herring and mackerel, all major canned fish products must be imported to completely satisfy the domestic demand. The most significant import is canned salmon, amounting to over \$100 million in 1980, or more than half the total. One steadily growing import commodity is canned tuna. While tuna imports only totaled \$23 million in 1980, they are rapidly becoming a major import commodity.

J. C. E. J. van der Eeden of Rotterdam, Holland, has prepared a 4-page report outlining the United Kingdom canned fish market. The report includes a product review of the six major canned fish products and advice on how to market these products in the United Kingdom. A copy of the report can be obtained by requesting the attachment to IFR-81/174, "The Market for Canned Fish in the United Kingdom," from your local NMFS Market News Office, enclosing a self-addressed envelope with \$0.37 postage.

Meetings, Missions, and Fishery Restorations

.... **The First International Symposium on Off-Flavors in the Aquatic Environment** will be held in Espoo, Finland, at the outskirts of Helsinki, 14-18 June 1982. The symposium will cover most aspects of flavor (odor and taste) problems in water and aquatic organisms (psychophysics, chemistry, biology, technology). The symposium is sponsored by the International Association of Limnology and various Finnish national bodies, including the Finnish Limnological Society and the Water Association of Finland. For further information, contact the secretary of the symposium, Taina Kuusi, Technical Research Center of Finland, Food Laboratory, Biologinkuja 1, SF-02150, Espoo 15, Finland . . .

.... **The 33rd Annual Tuna Conference is scheduled** for 16-19 May 1982 at the University of California Conference Center, Lake Arrowhead, Calif., reports Samuel F. Herrick, Jr., conference chairman. This year the conference will focus on ways in which available knowledge can be used to predict the outcome of various tuna management, utilization, and conservation practices. A panel discussion is also planned. Contact Herrick at the NMFS Southwest Fisheries Center, P.O. Box 271, La Jolla, CA 92038 for further information . . .

.... **An International Symposium on Tilapia in Aquaculture** will be held in Israel, 8-13 May 1983 to facilitate discussions between scientists, funding agency representatives, and aquaculture administrators. It will be conducted in English and will take place at the Ganei Hamat Hotel in Tiberias, Israel. For further information write the Organizing Committee, International Symposium on Tilapia in Aquaculture, P.O. Box 3054, Tel Aviv 61030, Israel . . .

.... **The U.S. Department of Commerce is sponsoring a trade mission** in August which will show fishing gear, marine equipment, processing equipment, electronic instruments, and fishing vessels. The mission will visit the following countries on the days noted: Panama, 8-9 Aug.; Costa Rica, 11-12 Aug.; Honduras, 13-16 Aug.; and Mexico, 17-19 Aug. For further information, contact Frank Manzollilo, Room 6015, U.S. Department of Commerce, Washington, DC 20230 . . .

.... The Plymouth Polytechnic Institute is sponsoring the **International Symposium on Fish Reproduction: Tactics and Strategies** on 19-23 July in England. For further information contact R. J. Wootton, Department of Zoology, University College of Wales, Aberystwyth, Dyfed, Wales, United Kingdom . . .

.... The Marine Technology Society, the Institute of Electrical and Electronic Engineers, and the Council on Oceanic Engineering are sponsoring the **OCEANS 82 Conference and Exhibition** at the Shoreham Hotel in Washington, DC, 20-22 September. It will focus on a description and a discussion of the ocean domain, how it may be rationally utilized, and how to promote its economic development. For further information write OCEANS 82, Marine Technology Society, Suite 412, 1730 M Street, N.W., Washington, DC 20036 . . .

.... **A record 530 Atlantic salmon returned** to the Connecticut River to spawn last year. The young fish from the 1.2 million eggs produced will be reared at State and Federal fish hatcheries and released into the river to help rebuild the fishery. The salmon disappeared from the Connecticut River 100 years ago after dams blocked the migration to upstream spawning areas. The restora-

tion effort, which began in 1967, involves the National Marine Fisheries Service, U.S. Fish and Wildlife Service (FWS), and the States of Connecticut, Massachusetts, New Hampshire, and Vermont, as well as two private power companies . . .

.... **American shad have spawned naturally** in the Susquehanna River for the first time in 150 years. That spawning followed the release of 1,165 adult shad in the river in May 1981 by the Pennsylvania Fish Commission and the FWS . . .

.... **About 2,000 endangered Kemp's ridley sea turtle eggs** were moved by U.S. and Mexican authorities from a Mexican nesting beach to Padre Island National Seashore in Texas where biologists are trying to establish a second, protected nesting beach. So the young turtles would become "imprinted" on Padre Island, they were allowed to hatch and make their way in the ocean before they were captured again and transported to a National Marine Fisheries Service laboratory in Galveston, Tex. There, they will be reared in captivity until they are about 1 year old, when they will be large enough to have a good chance of surviving in the wild. The sea turtles will then be released in Gulf waters, and it is hoped they will return eventually to Padre Island to nest . . .

.... For the first time ever, **two injured manatees were successfully released to the wild** in Florida after being rehabilitated in captivity. One of the large marine mammals was hurt when she became entangled in a crab trap line which wrapped tightly around her flippers. She was treated at Sea World and released successfully with her calf which had remained with her through the ordeal. Another female manatee, apparently struck by a boat, was rehabilitated by two other private groups under an arrangement with the FWS . . .

.... **Texas shrimpers enjoyed one of the best seasons** in years according to the Texas Parks and Wildlife Department. Landings of brown shrimp for the year were expected to exceed 45 million pounds. These near-record landings were attributed to favorable environmental conditions and management techniques . . .

Editorial Guidelines for *Marine Fisheries Review*

Marine Fisheries Review publishes review articles, original research reports, significant progress reports, technical notes, and news articles on fisheries science, engineering, and economics, commercial and recreational fisheries, marine mammal studies, aquaculture, and U.S. and foreign fisheries developments. Emphasis, however, is on in-depth review articles and practical or applied aspects of marine fisheries rather than pure research.

Preferred paper length ranges from 4 to 12 printed pages (about 10-40 manuscript pages), although shorter and longer papers are sometimes accepted. Papers are normally printed within 4-6 months of acceptance. Publication is hastened when manuscripts conform to the following recommended guidelines.

The Manuscript

Submission of a manuscript to *Marine Fisheries Review* implies that the manuscript is the author's own work, has not been submitted for publication elsewhere, and is ready for publication as submitted. Commerce Department personnel should submit papers under completed NOAA Form 25-700.

Manuscripts must be typed (double-spaced) on high-quality white bond paper and submitted with two duplicate (but not carbon) copies. The complete manuscript normally includes a title page, a short abstract (if needed), text, literature citations, tables, figure legends, footnotes, and the figures. The title page should carry the title and the name, department, institution or other affiliation, and complete address (plus current address if different) of the author(s). Manuscript pages should be numbered and have 1½-inch margins on all sides. Running heads are not used. An "Acknowledgments" section, if needed, may be placed at the end of the text. Use of appendices is discouraged.

Abstract and Headings

Keep titles, heading, subheadings, and the abstract short and clear. Abstracts should be short (one-half page or less) and

double-spaced. Paper titles should be no longer than 60 characters; a four- to five-word (40 to 45 characters) title is ideal. Use heads sparingly, if at all. Heads should contain only 2-5 words; do not stack heads of different sizes.

Style

In style, *Marine Fisheries Review* follows the "U.S. Government Printing Office Style Manual." Fish names follow the American Fisheries Society's Special Publication No. 12, "A List of Common and Scientific Names of Fishes from the United States and Canada," fourth edition, 1980. The "Merriam-Webster Third New International Dictionary" is used as the authority for correct spelling and word division. Only journal titles and scientific names (genera and species) should be italicized (underscored). Dates should be written as 3 November 1976. In text, literature is cited as Lynn and Reid (1968) or as (Lynn and Reid, 1968). Common abbreviations and symbols such as mm, m, g, ml, mg, and °C (without periods) may be used with numerals. Measurements are preferred in metric units; other equivalent units (i.e., fathoms, °F) may also be listed in parentheses.

Tables and Footnotes

Tables and footnotes should be typed separately and double-spaced. Tables should be numbered and referenced in text. Table headings and format should be consistent; do not use vertical rules.

Literature Citations

Title the list of references "Literature Cited" and include only published works or those actually in press. Citations must contain the complete title of the work, inclusive pagination, full journal title, the year and month and volume and issue numbers of the publication. Unpublished reports or manuscripts and personal communications must be footnoted. Include the title, author, pagination of the manuscript or report, and the address where it is on file. For personal communications, list the name, affiliation, and address of the communicator.

Citations should be double-spaced and listed alphabetically by the senior author's surname and initials. Co-authors should be listed by initials and surname. Where two or more citations have the same author(s), list them chronologically; where both author and year match on two or more, use lowercase alphabet to distinguish them (1969a, 1969b, 1969c, etc.).

Authors must double-check all literature cited; they alone are responsible for its accuracy.

Figures

All figures should be clearly identified with the author's name and figure number, if used. Figure legends should be brief and a copy may be taped to the back of the figure. Figures may or may not be numbered. Do not write on the back of photographs. Photographs should be black and white, 8 × 10-inches, sharply focused glossies of strong contrast. Potential cover photos are welcome but their return cannot be guaranteed. Magnification listed for photomicrographs must match the figure submitted (a scale bar may be preferred).

Line art should be drawn with black India ink on white paper. Design, symbols, and lettering should be neat, legible, and simple. Avoid freehand lettering and heavy lettering and shading that could fill in when the figure is reduced. Consider column and page sizes when designing figures.

Finally

First-rate, professional papers are neat, accurate, and complete. Authors should proofread the manuscript for typographical errors and double-check its contents and appearance before submission. Mail the manuscript flat, first-class mail, to: Editor, *Marine Fisheries Review*, Scientific Publications Office, National Marine Fisheries Service, NOAA, 7600 Sand Point Way N.E., Bin C15700, Seattle, WA 98115.

The senior author will receive 50 reprints (no cover) of his paper free of charge and 100 free copies are supplied to his organization. Cost estimates for additional reprints can be supplied upon request.

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